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GRAVEL SPREADER USED ON THE COLORADO RIVER LEVEE CONSTRUCTION.

By H. T. CORY,* Assoc. M. Am. Soc. C. E.

In Engineering News of Dec. 27 last, the author reported in detail the successive attempts made to close the crevasse in the banks of the Colorado River and turn it back to its old course to the Gulf of California. Since that date the final success of the closure works has been recorded in this journal, and in a recent issue (May 16) the construction of the levee system extending some ten miles below the closure works was described.

Because of the character of the material in these levees, the relatively high velocities of water to be expected flowing alongside them, the danger from burrowing animals and insects, and the difficulties of maintenance in an arid country, it was decided to blanket the system of levees with gravel. The material used was a cementing gravel obtained from the Mammoth Pit on the Southern Pacific main line 48 miles west of Yuma, Ariz., and a layer 1 ft. thick was put over the top and both slopes. The gravel was loaded into 45-yd. steel side-dump ballast cars by a 5-yd. Bucyrus steam shovel, and hauled east on the main line 40 miles to Hanlon Junction, and thence over the 7-mile branch line built by the California Development Co. last summer to the Hind-Clarke dam across the crevasse—a total distance of 47 miles. From this dam the levees run up the river 3¾ miles to the concrete diversion head-gate of the California Development Co., and down the river 11 miles, while a spur levee runs diagonally southwest 1¾ miles, thus making 16½ miles of the system which it was decided to build before this summer's flood.

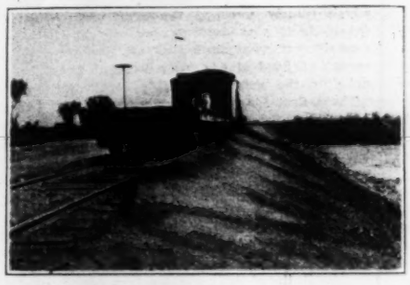
In order to distribute this blanketing gravel, as well as to facilitate maintenance, rigid inspection, and rapid repairs, track was laid on all the levees, consisting of 50-lb. second-hand rail in good condition and new pine 6 × 8 in. × 8 ft. ties, 16 to the rail length.

The levees are built 10 ft. wide on top, with side slopes of 1 on 3 on the land side, and 1 on 3 and in certain places 1 on 2½ on the river side. The gravel when dumped from the cars did not slide down these flat slopes, but formed ridges which just cleared the rail. Some method of cheaply and rapidly spreading the dumped material uniformly down the slopes was therefore imperative, for the total amount required to be moved reached some 250,000 cu. yds.

Mr. Thomas J. Hind, who was superintendent of closing the first break, and later of the levee construction, attacked the problem, and designed a remarkably simple, cheap and efficient spreader. It has done the work splendidly; and curiously enough the machine as first built has not been changed in any particular, nor have any improvements been suggested by the extended experience with it, although it has been subjected to severe tests—such as stalling the Mogul locomotive by which it was driven under a heavy cut of gravel. A possible exception might be the suggested use of compressed air to raise and lower the wings, but even this change the writer considers of very doubtful desirability in the light of experience with the McCann spreader, for this class of work particularly.

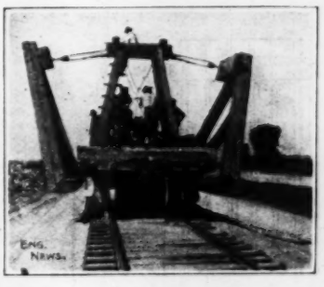
The spreader is built on an ordinary flat car, and is of extremely simple construction. In the center a small well-braced tower is built. On each side 8 × 17-in. pine stringers are firmly bolted to the side sills, and to stringers laid across the top of the car body. Ten 1¼-in. eye-bolts run up through these stringers, and from these are suspended two isosceles triangular wings, one on each side of the car. These wings are raised and lowered by means of ropes and blocks at the points of the wings and at the top of the tower. The wings are raised by setting brakes on the car and hauling on the rope with the locomotive, and are very easily and satisfactorily lowered by hand.

The accompanying drawing gives sufficient details to construct the machine. The car is weighted with steel rails to prevent any tendency to derail when the work done by the two wings is unequal, or when gravel is left on the rail when the spreader is pushed ahead of the locomotive. The wings of the machine are faced on the outside with ⅜ × 8-in. iron, and in place of having a shear, as in a plow, are vertical. For long-continued use the bottom of the wings should also be faced with iron as the unprotected timber showed decided wear. The wings can be set to give any desired thickness of blanketing—within reasonable limits—and in this spreader they were designed to cut the gravel heap at the base of rail and level it for a top width of 10 ft. The wings used had a reach (altitude of the triangle) of 15 ft., this being the minimum length of the slope where the levee was lowest. The height of the plow arm is only 16 ins., but there is practically no spilling over of material under the heaviest cut, and the interior of the wing does not catch any gravel—the amount of play in the eyebolt connections of the wings to the car allowing the front leg of the triangle to dig down and the rear leg to rise just enough to prevent any trouble of this kind. The spreader being symmetrical about the cen-



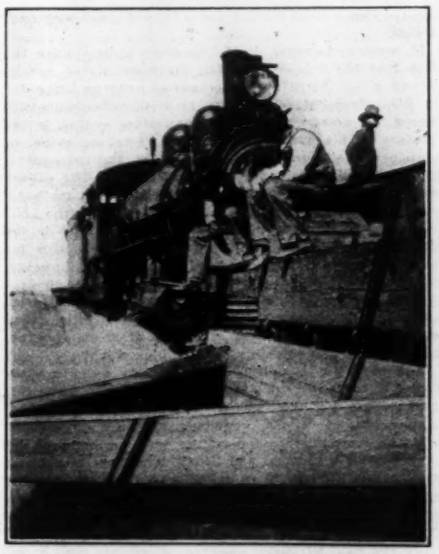
Spreading Second Cut of Gravel Down the Bank.

A Stretch of Finished Work.



Raising Wings by Locomotive Power.

WORK OF A LOCOMOTIVE GRAVEL SPREADER ON THE COLORADO RIVER LEVEE.



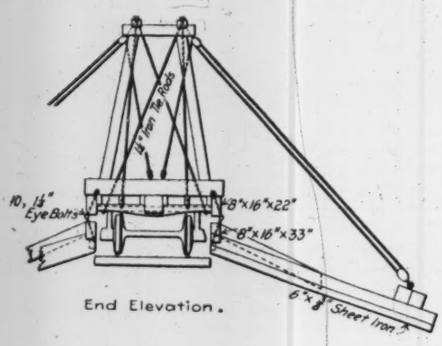
Leveling Top of Bank with Wings Level.

*General Manager and Chief Engineer, California Development Co., Calexico, Cal.

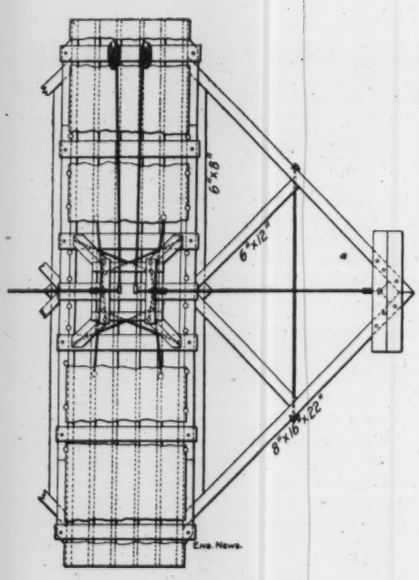
ter—that is, double-ended—it works in either direction, and in addition it is found a matter of indifference whether it is pushed ahead of the engine or pulled behind it. The weight of each wing is approximately two tons.

The 45-yd. side-dump ballast cars which were used in this work were unloaded when standing still—except in finishing off—so the top of the dumps on either side set from 3 to 4 ft. above the track, the inside slopes running to the rails. The material from each cut of cars was spread down the slopes before a second cut would be unloaded at the same place, three cuts being the maximum required to blanket the levee at any point, and two sufficing in the stretches where the levees were lowest.

In spreading these cuts of material down the slope, the spreader is run up to the work, the



End Elevation.



Plan.

Plan and Cross-Section of Gravel Spreading Car.

wings lowered until about level, and the machine put through the entire length of the cuts, frequently at a speed of from 7 to 10 miles per hour. The wings are then lowered farther, and a run is made in the reverse direction. With the material and slopes used, one round trip distributed the material on the first cut, and never more than two round trips were required to thoroughly and uniformly spread the second and third cuts of gravel over the slopes, and throw the excess material beyond the points of the wings.

Mr. F. B. Gowlag, Assistant Engineer on levee construction, has taken some good photographs of the spreader, which are given herewith. He also reports that the machine handled about one-third of the material of the first dumping or cut (because of raising and surfacing the track from it) and practically all of the second and third dumpings, and that the following are average results obtained in its use:

Cut	1st.	2d.
Distance in feet	7,500	2,100
Number of car loads	250	70
Runs required	2	2
Time required	25 mins.	9 mins.
Percentage of dump handled	33⅓%	75%
Cubic yards handled per hour	8,000	14,000

The cost of work done by the machine per yard of material spread is slightly under 1/10 ct.

The cost of constructing the machine was approximately $300, and its operation requires the service of a locomotive and of four men to handle the wings.

CLOSING THE COLORADO RIVER CREVASSE.

As our readers will recall, we have from time to time during the past two years reported in these columns the consecutive events in connection with the remarkable crevasse in the Colorado River banks.* Several of these articles have been contributions prepared especially for Engineering News by the engineers in direct charge of the work. Among these contributors has been Mr. H. T. Cory, M. Am. Soc. C. E., the Chief Engineer and General Manager under whom the work has been carried to a successful conclusion. We find in the "Purdue Engineering Review" (the annual published by the engineering societies of Purdue University) a paper by Mr. Cory which reviews the events in connection with this remarkable work from start to finish, and presents the engineering problems involved and precedents established in a clearer manner than has ever before been done. As these precedents are of much importance in connection with the control of river currents and the construction of dams and levees on soft foundations, we deem it worth while to reprint Mr. Cory's paper in full below:

International interest has been aroused by a curious freak of a curious river, resulting in conditions and situations quite without a parallel in the world's history—the breaking by the Colorado River of its western bank just south of the Mexican International line and with marvelous rapidity forming a new channel through which all its waters were diverted into one of the most remarkable basins lying below sea level—the Salton Sink.

The necessity of diverting this river back to its old channel was early seen to be imperative, but at the same time the case was without precedent in modern times, and hence it is not remarkable that the earlier efforts were unsuccessful. When the desperateness of the situation was fully brought home by these failures, heroic measures were taken, measures the success of which depended entirely upon ability to do work faster than the river. Like the break itself, the engineering problems presented were unprecedented, and the solution was quite as much of a freak as anything else about the entire matter. Engineering principles have been studied to such a degree, and the sum total of engineering experience so classified and systematized that ordinarily the paths to desired results are not only well blazed, but usually absolutely determined, individual judgment being very largely confined to details. Entirely new trails are rare, and even then, very few are more than extensions of the frontier clearings as it were, carrying developing types of construction a little further and a little further with each design.

In passing, however, it is important to emphasize the fact that the *details* are vital, far more of the wrecks strewn along the pathway of material progress being due to illy considered details than to designs fundamentally wrong. A great engineer, like any other genius, is one because of his exceptional capacity of taking pains, of anticipating all possibilities of weakness, and consequently, successfully designing to prevent them. The college graduate knows the paths, the principles and methods; only experience in particular lines will develop the ability to successfully handle details—and just here is the difference between a college graduate, or professor for that matter, and an engineer. It is necessary, however, to add that powers of observation and good judgment are so different in individuals that many men out from their Alma Mater are far stronger in these directions than others who were members of classes of years gone by. "But this is another story," as Kipling would say.

And so it happens that the opportunity to be a pathfinder in engineering methods is relatively rare; and this is fortunate for the individuals, everything considered. Engineering operations, nowadays, are on a large scale, and the responsibility for results with an immense lot of expensive equipment and heavy daily pay rolls has a very marked tendency to take away the keen edge of satisfaction in one's gratification of scientific curiosity, or, as it is usually put, in scientific research. If, in addition, vast interests are at stake and everything is lost unless victory is obtained in a time long enough but for a couple of attempts at most, conditions more favorable for premature gray hairs than anything else.

There was one other feature in the last closing of the Colorado River crevasse, and that was, a unanimity of the authorities that the methods employed were certain to fail under the circumstances.

No less than five futile attempts were made before the first crevasse was closed, and, in a sense, four trials were required before the second closure was made. While these statements are misleading without explanation, they indicate the necessity of perseverance, rapid changes of plans, and either the difficulty of the problem, the unwise methods employed, or both.

The first two attempts were on a small scale, consisted in trying to build dams across the breach of piling, brush, and bags of sand, while the break was in its incipiency. The first attempt was successful in that the break was actually closed but the dam gave way in a few hours. At this time the break was but 65 ft. wide. The second attempt was a complete failure, due to the method employed and to the fact that it was begun just as the annual spring rise of the river had well started. The third attempt was an endeavor to divert all the water of the river to the opposite side of Disaster Island from the crevasse by driving a row of piling from the up-stream end of the island, inclined up-stream to the west bank of the river. Disaster Island was about a mile long, the break being in the west bank of the river about midway of the island. This row of piling had little effect in spite of the fact that brush was used with it, so a second row was started a quarter of a mile farther up-stream. Still no better results were obtained and the whole plan was abandoned.

By this time the seriousness of the situation was beginning to be appreciated, and an elaborate pile, brush, and sand-bag dam was started across the channel between the island and the west bank of the river, about half way between the head of the island and the crevasse. It was well along when a severe flood occurred which utterly wrecked the structure. When the flood subsided, it was evident that the entire island would soon be cut away, and that all the water in the river, except at flood stages, was diverted from the old channel into the new one leading to the Salton Sea.

These first four attempts to remedy the situation have been hurriedly treated, because there was nothing novel about any of them. The methods were standard and often employed in all times and all places. The failures were due to the methods being inadequate by the time work on them was begun. By January, 1906, the situation had grown very serious, and was attracting attention throughout both the United States and Mexico, particularly among irrigators and engineers. The Salton Sink had become the Salton Sea, forcing the Southern Pacific Railroad to move its trans-continental tracks to higher ground, for miles and miles. The new river, because of its great fall—from elevation 110 above sea level at the crevasse to elevation 230 below sea level at the sea, within a distance of 110 miles—was forming a canyon by the recession of the grade at such a rate as made it evident that a single summer flood was all that could come that way before the grade recession would utterly destroy the entire irrigation system of the Imperial Valley.

Such a calamity would force the emigration from their homes of ten thousand people, living in five towns and cultivating one hundred and twenty-five thousand acres.

The old river channel had silted up and at the crevasse the new channel was slowly, but surely, lowering, so that it seemed probable when the summer floods should have passed, it would be necessary to raise the water at the crevasse about 10 ft. to divert it down its old bed. The old and new channels of the river were in a silt material extending uninterrupted to unknown but very great depths, material which melts with such astounding rapidity that a river through it has practically no bottom or sides to which to tie anything. Rock dropped into the river's bottom soon settles out of sight, and according to old river men, doubtless never stops settling through the quicksand until bed rock is reached. At any rate every steamboat, flat-boat, or dredger which had ever sunk in the river, settled entirely out of sight, even the tops of flag-staffs and masts disappearing in a few months.

Such were the conditions on Jan. 1, 1906. It is no great wonder that not one of the many engineers of extensive reputation and experience, who visited the scene, thought there was more than a chance for success.

The plan of the fifth attempt, which was begun Jan. 8, 1906, was to build a mammoth wooden A-frame flash-board headgate along the banks of the crevasse, and divert the river through it while building an earth dam across the break immediately opposite, and when such dam and the levee system necessary to prevent overflow water from getting around the ends of the dam should be completed, the flash-boards could be put in the gate, and hence the crevasse closed.

The chief engineering features of the gate were its size—200 ft. in length, 25 ft. height of A-frames, and 60 ft.

*See Engineering News, Feb. 22, March 15, May 10, June 28, Dec. 27, 1906, and Jan. 3, 17, 31, Feb. 7, 21, and May 16, 1907.

width of floor up and down stream; the speed of its construction—work being rushed on it night and day almost continuously; the cutting of but small channels from above and below it into the crevasse—depending upon enlarging these sufficiently by sluicing to carry the entire low-water flow of the river; and the daringly modest foundation for so huge and important a structure—erroneously considered advisable because more elaborate construction would have required longer time. Although rushed all possible, delays occurred to such a degree that before the gate was ready the annual spring and summer rise had commenced, and so it was necessary to delay building the dam across the crevasse until this flood had subsided.

The extent of an obstruction which it would be necessary to put in the river to force all the water through the gate was more a matter of conjecture than precise calculation, since all depended upon how easily the narrow "by-pass channels" would sluice out. Estimates as to the difference of head which would be required above and below such an obstruction or dam varied from 1½ ft. to 6 ft. To the surprise of most people, the actual head required was 5.8 ft. An obstruction to produce a couple of feet head would of course need to be nothing elaborate—a pile, brush and sand-bag weir would serve every purpose. For this head a branch railroad would under no circumstances be needed. But to develop a head of 6 ft. in a river with silt—practically quicksand—bottom and sides, is an entirely different matter. Fear of the wooden headgate's failing, as well as the belief that the chances were even that a head of 6 ft. would be required against the California Development Co. and in general charge of operations on the completion of the gate, to build a branch railroad to the headgate from a point on the Southern Pacific main line six miles west of Yuma—a distance of seven miles—and to develop a quarry, a gravel pit, and a clay pit, about midway of this line and put a steam shovel in each.

Work upon the weir across the channel opposite the headgate was begun as the summer flood subsided—August 10. A brush mattress, 18 ins. thick, 100 ft. wide up and down stream, and extending entirely across the channel—800 ft.—was woven on a barge continuously across the channel, and sunk. No weighting was required, the interstices silting up almost instantly because of the immense amount of suspended matter carried by the water. Over a considerable portion a second mattress equally wide was sunk, and in the deepest places a third. Through the center of these an ordinary four-pile railway trestle bridge was driven, except with 10-ft. bents instead of the usual 15 or 16-ft. openings. With a little brush, and considerable rock obtained from the quarry already mentioned, loaded into 45-yd. steel side-dump automatic cars by a steam shovel, and unloaded from the trestle, the weir was built up until practically no water was going over it, the headgate carrying the entire river. Just at this juncture, the gate suddenly rose near the center, and over half of it broke loose entirely and floated away, going aground a couple of hundred feet down stream.

Such an ending of this attempt was by no means unexpected, but the effect was nevertheless disconcerting to the official staff, to say the least, and thoroughly demoralizing to the men. The total result of all endeavors to divert the Colorado down its old channel was that the river was confined to a width of 150 ft. between the remains of the wooden headgate, but with a depth of over 20 ft. and a very swift current. Furthermore, the channel was very tortuous, but with particularly sharp bends where the by-pass channels left and entered the banks of the crevasse, and every bend was cutting badly.

Plans had been fully matured for just such a contingency, but with two tracks over the narrow by-pass channel and a third one a matter of but a week's time, the possibility of building in this unstable soil, three rock-fill dams in series, each with a head of 2.8 ft. or a total head over all of the 8.4 ft., necessary to turn all the water back over the dam in the main channel of the crevasse, and then build this dam (which would be kept from settling into the river bed by the immense mattresses) up high enough to turn the river—this possibility constantly recurred while sullenly watching this little narrow, swirling, coffee-colored stream that had so far baffled every effort to control it. Of course everybody knew it could not be done unless rock could be put in faster than it would settle into the jelly-like soil and be carried away by the seething current. To work faster than the river. Could that be done?

Nobody knew how fast the river would work, but a careful survey of the possibilities of the "plant," of all the quarries within a radius of 500 miles, and of the equivalent of the Southern Pacific Co., showed very large quantities of rock could be rushed into place per day—and why not try it? A race with Dame Nature would certainly be interesting, at least, and though the cost would be enormous and the chances of success slight, the stake was stupendous. So in a relatively few hours, the well studied plans worked out for just this contingency were filed away for the time being—but not, however, until after all the material needed for them and not already on hand, had been ordered by telegraph to be rushed forward with all dispatch—and repairs started on the two trestles over the by-pass channel, which had been damaged considerably both by the rush of water when the gate let go and by the debris therefrom.

A few hours after that a third trestle was started; night and day work had begun in every available quarry on the Southern Pacific Railroad, from Los Angeles to New Mexico, and the transportation officials had begun gathering up flat cars from every quarter, to handle the output. The water in the Salton Sea had risen to within a few feet of some forty miles of new track which the Southern Pacific had built high enough, it was thought, to be out of the water's reach for three years to come, and its situation was desperate. Consequently the entire resources of the company were placed at our disposal, and it is very doubtful whether so heavy a draft has ever been made upon a railroad in the United States in time of peace.

The pace was terrific; even the common laborers were infected with the excitement of it, and the river lost by a wide margin—in fact, just three weeks and four hours after dumping the first car load of rock into the by-pass channel the river was entirely diverted, not over 20 sec. ft. of water percolating through the dams. In addition to working much faster than the river, there had been accomplished something which the most eminent hydraulic authorities advised was impossible—the building of a rock-filled dam 400 ft. long and 16 ft. high across a river which never carried less than 9,000 sec. ft.

The jubilation of everybody concerned was pronounced but shortlived—from November 4 to December 7. On the latter date, a heavy flood caused a break in the levees a half mile below the end of the dam just completed and in relatively few hours the Colorado was once more on its way to the Salton Sea.

After appeals to both President Roosevelt and President Diaz, considerable correspondence between President Roosevelt and President E. H. Harriman, of the Southern Pacific Company, and the assurance that Congress would be asked to make a special appropriation for the purpose; on Dec. 22, President Epes Randolph, of the California Development Co.—the irrigation company in whose name all diversion operations were carried on—received permission to proceed with this closure, and a half hour later his telegraphic instructions were received at the scene of the break and slipped the leash from the impatient forces which had long before completed every preparation and were chafing under inactivity and suspense.

For this closing was far more daring than the first. Then the discharge was practically certain not to exceed 10,000 second-feet; now it was the season of severe floods out of the Gila, which empties into the Colorado just above Yuma and has almost the whole of Arizona, a quarter of New Mexico and quite a large area of Old Mexico, as its watershed—a watershed larger than that of the Colorado proper, and, in general, remarkably precipitous and barren. Then the final rock-fill dam across the crevasse was founded upon an extraordinarily substantial brush and steel cable mattress; now, because the probable time between floods was so short, it was decided to omit the mattress and found the dam on the fine and easily eroded river silt. Then the crevasse was narrow, the main dam being 400 ft. long; now the crevasse was 1,100 ft. wide and 35 ft. deep in the channel. Then the dam was straight; now, to connect with the levee, it was concave up stream on a 6° curve. Then there were no other features to distract attention, except extension of the levees; now the river made a sharp curve against the sand embankment adjoining the first or Hind Dam on the down-stream end and literally turned on edge, necessitating the most heroic work to prevent side-cutting entirely through—so heroic, in fact, that practically every visiting engineer considered losing the embankment and being thus outflanked as practically inevitable.

Four times—Jan. 1, 9, 19 and 27—the lower trestle was practically ready to start dumping rock therefrom, but Gila floods carrying enormous quantities of drift, three times by the narrowest of margins, won the race of floods against bridge building. The last race the river lost by 36 hours. In the first twelve hours after the track across the break was ready, from six o'clock in the evening to six o'clock the next morning, 7,500 cu. yds. of rock were unloaded from it, and in the first 48 hours 12,000 yds. The flood with apparently human vindictiveness at being beaten, hurled its immense cargo on drift against the upper trestle—for two trestles were thrown across the break as nearly 50 ft. apart as the conditions allowed, thus carrying out the series-dam idea—and, as it was nearly completed, the danger of its being torn out and hurled against the lower one, hopelessly destroying the latter, was imminent. Few, if any, on the works ever saw as desperate a situation saved, ever saw a more desperate struggle than took place with the drift along the upper trestle throughout that stormy night when the flood was at its worst. Although three bents in it were lost, yet, thanks to the pond effect caused by the incipient dam, the damage to the lower trestle was held down to displacing the up-stream pile in each of two bents, and both these latter, by a rare chance, had middle piles under the up-stream stringers. Almost, but not quite as desperate, was the struggle to repair the breaks in the trestles after the various floods. The current veered to an angle of about 45° with the line of the trestles after the first trestle washed out, and driving 90-ft. piling in 35 ft. of water, running like a mill-race and carrying large amounts of drift, with ordinary top drop-hammer pile drivers was the most difficult work of the kind of which the writer knows. With the Colorado break, as with almost every other desperate struggle, "the men behind the guns" deserve the larger share of the credit. The unflinching night-and-day struggle for three weeks on the creaking, lurching, dangerous pile drivers, and the apparently hopeless, yet successful, struggle with drift along the upper trestle just referred to deserve a place beside the more thrilling deeds of heroism of the frontiersman and the soldier in our western country.

Mr. L. C. Hill, Supervising Engineer of the United States Reclamation Service, in charge of the Roswell, the Salt River, and the Yuma projects, which include, among other notable features, two of the most remarkable dams of modern times, writes in the Pacific Monthly for April:

> The closing of the break in the Colorado River, which was concluded on the afternoon of Feb. 11, was a remarkable achievement. In the handling of rock and earth a record was made which is likely to stand for many years to come. The time actually consumed in making the closure, dating from the dumping of the first rock, was 15 days and two hours, during which interval 77,000 cu. yds. of material, 95% of which was rock, the balance gravel and clay, was handled.
>
> The difficulties which confronted the engineers will be better appreciated when it is recalled that the Colorado River, with a flow of 22,000 second-feet, was rushing madly through a break 1,000 ft. long in soft earth banks. In mid-channel, the depth of the water was 34 ft. The maximum amount of water contended with during the construction of the dam approximated 40,000 second-feet. In a period of a little more than two weeks a structure of rock, gravel and clay has been built across the channel.
>
> * * * * * * * * *
>
> The foundation of this dam is silt almost as fine as ashes and as easily eroded. The entire equipment of the Southern Pacific has been at the command of the engineers during the period of the work. * * * * contributing material to close the break. A great railroad corporation * * * * and quarries hundreds of miles distant, with abundant rolling stock, alone could have achieved this feat, and success, even then, would not have followed if the work had not been intelligently directed by competent engineers. Temporarily, at least, the Colorado has been conquered, but, like the Mississippi River in its Delta region, it will bear watching.

The completed dam contains 200,000 cu. yds. of material, about 50% of which is rock, the balance being gravel and clay, which was added to make the structure impervious. After the closure had been made, additional material was added at the rate of 5,000 cu. yds. each 24 hours.

All the while, work on strengthening and extending best, levees, especially new ones, are not infallible. Since 1,500 horses being employed and a million yards of dirt moved from Jan. 1 to March 1. The levees are unusually well built, but the soil makes a poor foundation, and, at best, levees, especially new ones, are not infallible. Since the levee system is fifteen miles long, a Colorado crevasse is possible every flood, and the probability that another crevasse may occur within the next five years is quite large.

However, such an outlook is no longer dreaded—closing Colorado River crevasses has been reduced to a system, almost to a routine. The expense is very great, but in future will be much less, as the quarry on the branch line has been developed sufficiently to furnish all the rock which would be necessary, thus eliminating the expensive main line haul. A well-ballasted railroad track is laid on top of every foot of the levees and under ordinary circumstances a trestle could be thrown across a break within a week. Three weeks at most, then, should see the closing of the next crevasse—in short, the method is already "standardized."

For general application, it has been shown that by rapid work, presupposing railway facilities, it is possible:

First—To build a rock-lam across a river in an alluvial plain, and,

Second—To build a rock-fill dam at least 14 ft. high across a river with a discharge as much as 75 cu. ft. per second per lineal foot of dam by dumping rock from a single line of trestle.

Mr. Epes Randolph, President of the associated Harriman lines in Arizona and Mexico, has been president of the weir in the river, caused the writer, who took charge of the Colorado division work from June, 1905, to date; Mr. C. R. Rockwood was Chief Engineer from 1899 to April, 1906, and built the mammoth wooden or "Rockwood Gate;" Mr. Thos. J. Hind was Superintendent of the first closing or "Hind Dam," and of the reconstruction and extension of the levees since Dec. 15; Mr. C. K. Clarke was superintendent of the last closing or "Clarke Dam." The two dams really adjoin and make one continuous structure, known as the "Hind-Clarke Dam." The writer has been General Manager and Chief Engineer of the company since April, 1906.

DIAGRAMS FOR THE DESIGN OF REINFORCED CONCRETE BEAMS.

The solution of the formulas for the analysis or design of a reinforced-concrete beam lends itself so readily to graphical representation that probably most men engaged in reinforced-concrete calculations have drawn up diagrams for facilitating the work. Numerous diagrams of this kind which we have received illustrate the fact—evident enough on reflection—that they generally differ but little either in principle of construction or in convenience of use. There are two parts to the problem of designing a beam, which must be solved consecutively: First, given two of the three quantities: stress in steel, stress in concrete, and percentage of tensile reinforcement, find the third quantity and the coefficient K in the equation of resisting-moment

$$M = K\,bd^2.$$

Second, knowing the external bending moment and the coefficient K, find the value bd^2 by division, and from this, by selecting either the breadth b or the depth d, compute the other. This second operation may be performed graphically by a set of parabolic curves drawn to coordinates M and d. The other operation requires a separate diagram, containing curves connecting three of the fundamental variables: stress in steel, stress in concrete, percentage of reinforcement, and moment coefficient K; and another set of curves connecting the fourth quantity with any two of the first three. If it is desired to introduce as a variable n, the ratio of moduli of elasticity, to allow for different mixtures of concrete or different specifications as to values of n this may be accomplished by drawing several diagrams, each for a single value of n, or by a compound diagram. Compound diagrams, however, are generally undesirable.

A novel feature is contained in the accompanying three diagrams, drawn up by Mr. F. Teichman, Engineer with the United States Reclamation Service at Roosevelt, Ariz. This is the addition of a set of curves for determining the size of reinforcing rods in order to limit the bond stress or the shear along the surface of the steel. The following statement of the make-up and use of the diagrams is given by their author.

The formulas that are used in making the diagrams are based on the following assumptions: 1. Sections plane before bending are plane after bending. 2. The steel carries all tensile stresses. 3. The diagram of concrete stresses is triangular with apex in neutral axis; i. e., the modulus of elasticity is constant for all stresses. 4. There are no initial stresses in the material.

The symbols used in the formulas are:

$n = E_s/E_c$ = ratio of moduli of elasticity of steel and concrete.

d = depth of beam in inches from extreme compressed fiber to center of gravity of reinforcement.

x = distance of neutral axis from extreme compressed fiber.

$r = x/(d - x)$ = ratio of distances to neutral axis.

$m = d - x/3$ = distance of reinforcement from resultant of compressive forces.

F = area of steel per inch width of beam.

$p = 100\,F/d$ = percentage of steel in concrete.

C = unit compression of extreme fiber of concrete. In the diagrams this is required not to exceed 700 lbs. per sq. in.

T = unit tension in steel. In the diagrams not to exceed 17,000 lbs. per sq. in.

A = unit adhesion of concrete to steel. The diagrams are based on the limiting value 64 lbs. per sq. in.

M = bending moment in inch-pounds per inch width of beam.

V = shear per inch width of beam.

For an assumed value of n, r depends only on the percentage of reinforcement:

$$r = \frac{n\,p}{100}\left(1 + \sqrt{1 + \frac{200}{np}}\right) \qquad (1)$$

The stress in the steel, in relation to the stress in the extreme compressed fiber of the concrete, is determined by n and r:

$$T = \frac{n}{r}\,C \qquad (2)$$

The lever-arm of the internal bending stresses in proportion to the height of the beam is

$$\frac{m}{d} = 1 - \frac{r}{3\,(1+r)} \qquad (3)$$

The moment of the couple of the internal bending stresses is

$$M = F\,T\,m = \frac{p\,T}{100}\,\frac{m}{d}\,d^2$$

or

$$M = a\,d^2 \qquad (4)$$

where

$$a = \frac{p\,T}{100}\,\frac{m}{d}$$

from which

$$T = \frac{100\,a}{p\,\frac{m}{d}} \qquad (5)$$

These five equations give the stress diagrams.

Three diagrams were made [Figs. 1, 2 and 3 herewith], one for each of three values of n, namely $n = 11$, $n = 13$, $n = 15$. In each of them p is measured off horizontally, T vertically, there being on the diagram curves for C and a to these coordinates. The curves of C are obtained by eq. (2) after substituting from eq. (1) the value of r in terms of n and p. The curves of a are obtained from eq. (5) after substituting the value of m/d in terms of n and p given by eq. (1) and (3).

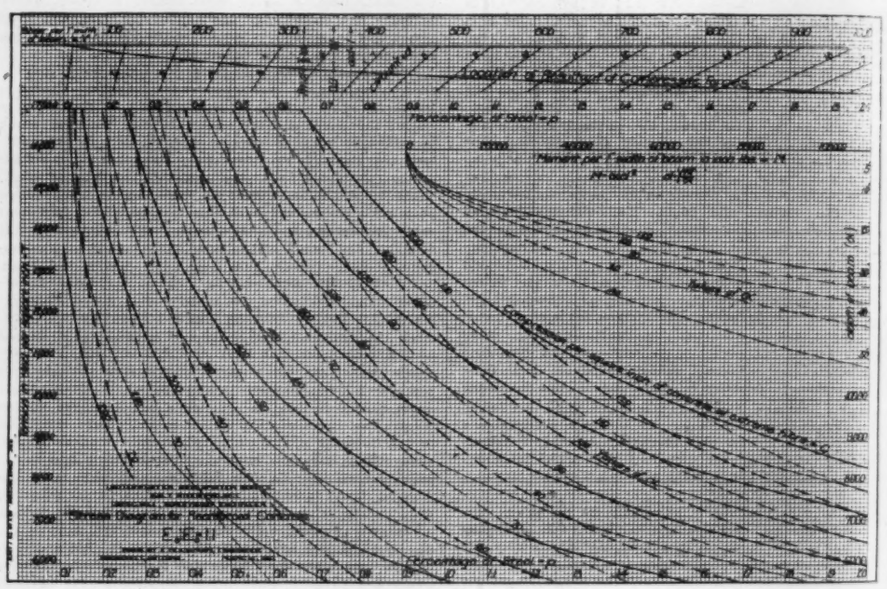


FIG. 1. DIAGRAM FOR REINFORCED CONCRETE BEAMS FOR $\frac{Es}{Ec} = 11$.

F. Teichman, Roosevelt, Arizona.

To the right of the stress diagram in each figure is shown the moment diagram, connecting the values M, d and a in the manner expressed in eq. (4). The curves (parabolas) of this diagram are in denomination the same as those of the stress diagram.

Above the stress diagram in each figure is a curve which gives $\frac{x/3}{d}$ and $\frac{m}{d}$ as functions of p [eq. (1) and (3)]. These curves are made use of to find the quantity (circf. × d), i. e., the circumference in inches of the reinforcement bars per inch width of beam, multiplied by the depth of beam, the value of this quantity in the diagrams being such that the required unit adhesion of concrete to steel will not exceed the stipulated amount 64 lbs. per sq. in. We get an expression for (circf. × d) if we consider that the equilibrium of a slice of the beam, lying between two cross-section planes 1 in. apart, requires that the moment of the shear couple equals the moment of the bonding stress.

$$V \times 1'' = \text{circf.} \times 1'' \times A \times m,$$

$$\text{hence (circf.} \times d) = \frac{V}{64\,(m/d)} \qquad (6)$$

Accordingly (circf. × d) can be taken from the diagram by the coordinates V and the value of m/d pertaining to p.

The quantity (circf. × d) is a maximum for V maximum, i. e., commonly for the end shear of a beam. For such case eq. (6) neglects the advantage as to adhesion resulting from the fact that the bars project into the concrete beyond the line of reaction.

The value (circf. × d) as determined above is good for plain bars, round or square. The actual (circf. × d) may be made larger than the quantity determined by equation or diagram, but should not be any smaller, otherwise the unit adhesion actually required will be larger than stipulated.

The relation between area and circumference, for both round and square bars, is

$$\frac{\text{Area of bar}}{\text{circf. of bar}} = \frac{\text{diameter}}{4}, \text{ or } D = \frac{4 \text{ area}}{\text{circf.}}$$

This equation applies not only to the values of area and circumference pertaining to one bar, but equally well to the values pertaining to inch width of beam. According to definition the area of steel per inch width of beam is

$$F = \frac{pd}{100}$$

Combining this with the preceding equation,

$$D = \frac{pd^2}{25\,(\text{circf.} \times d)} \qquad (7)$$

This equation gives for beams of constant depth and reinforcement (i. e., straight beams, where the bars required for the maximum bending moment run through to supports) an expression for the maximum allowable diameter of the reinforcing bars, the value (circf. × d) being determined by the diagrams or by eq. (6) for V_{max} (commonly the end shear). For a diameter larger than this the actual unit bond stress will exceed the stipulated amount, and for a smaller diameter it will be below it, i. e., on the safe side.

The equations (1) to (7) and the diagrams may be used for slabs, for rectangular beams, and also for T-beams formed by combination of beam and slab, as long as the neutral axis lies inside the slab, i. e., if thickness of slab is equal to or

greater than $3d\left(\frac{x/3}{d}\right)$ the quantity $\frac{x/3}{d}$ being found from the diagrams. In case of beams and slabs we may figure as the compression width of beam the distance of beams c. to c., but not exceeding one-third the effective span of beam (this is a simple rule of the German Government regulations).

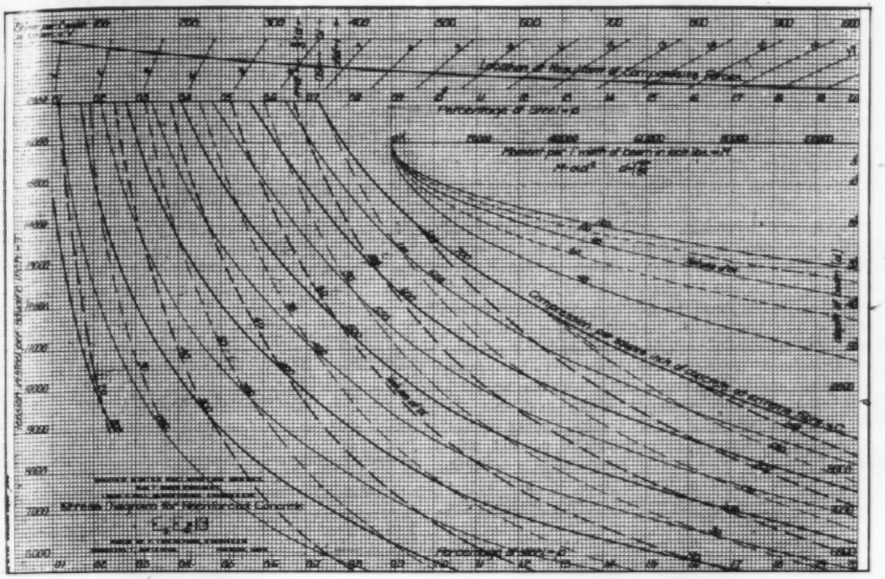


FIG. 2. DIAGRAM FOR REINFORCED CONCRETE BEAMS FOR $\frac{Es}{Ec} = 13$.

F. Teichman, Roosevelt, Arizona.

The total moment of beam divided by this compression width of beam in inches gives the M per inch width of beam, to be used in referring to the diagrams. After the amount of steel is determined for this compression width of beam it is bunched in a narrow width, the tension width. This tension width of beam may be chosen so that the horizontal unit shear in the tension leg shall not exceed 70 lbs. per sq. in. This condition gives the formula

$$\text{width} = \frac{V}{70\frac{m}{d}d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The value m/d does not vary very greatly, so that 70 m/d averages about 64, the same value as was assumed for the bonding stress in making the diagrams. We can then simplify formula (8) to read

$$\text{width} = \frac{V}{64\,d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

This means that a beam of width equal to the tension width and of depth d should take up the total vertical shear with a mean shearing stress of about 64 lbs. per sq. in., if the permissible unit shear is 70 lbs. per sq. in. The width determined from this consideration may be reduced if inclined or vertical rods are imbedded in the concrete of the beam in the region of greatest shear.

To illustrate the use of the diagrams, the following example will be calculated by their aid: A floor of 18-ft. span is to be designed to support a load of 220 lbs. per sq. ft. including its own weight. The value $E_s \div E_c = 15$ will be assumed (Fig. 3).

End shear per inch width of floor = 165 lbs. Max. moment for effective span of 18.5 ft. = 9,412 in.-lbs. per inch width of floor.

We select $p = 1.01\%$, $C = 433$ lbs. per sq. in., and from Fig. 3 find the values $T = 9{,}000$ lbs. per sq. in., $a = 78.2$. Entering the moment diagram in Fig. 3 with $a = 78.2$ and $M = 9{,}412$ we find $d = 11$; this is better calculated from formula (4). The amount of steel is then

$$F = \frac{1.01 \times 11}{100} = 0.111 \text{ sq. in. per in. width.}$$

Referring to the shear diagram in Fig. 3, follow the vertical through $p = 1.01$ to the curve marked "Location of Resultant of Compressive Forces." Follow horizontally to intersection with the vertical through $V = 165$. Reading on the diagonal line we find the value (circf. $\times$ d) = 3. Then from eq. (7) we obtain the required diameter of round reinforcing rods

$$D = \frac{1.01 \times 11 \times 11}{25 \times 3} = 1.63 \text{ ins.}$$

If we select 1-in. bars, area 0.785 sq. ins., their spacing would be 0.785 ÷ 0.111 = 7.07 ins. If we select ¾-in. bars, area 0.442 sq. ins., their spacing would be 0.442 ÷ 0.111 = 4 ins. Only every other one of these bars need run through to the supports of beam, since for ¾-in. bars 8 ins. c. to c. the value (circf. $\times$ d) per inch width is $\frac{0.75 \times 3.14}{8} \times 11 = 3.23$ ins. The other half of the bars may run between points where the external bending moment is ½ × 9,412 in.lbs., i. e., for a length of about ¾-span and then the bars may be bent upward at 45° to take up combined tension and shear stresses.

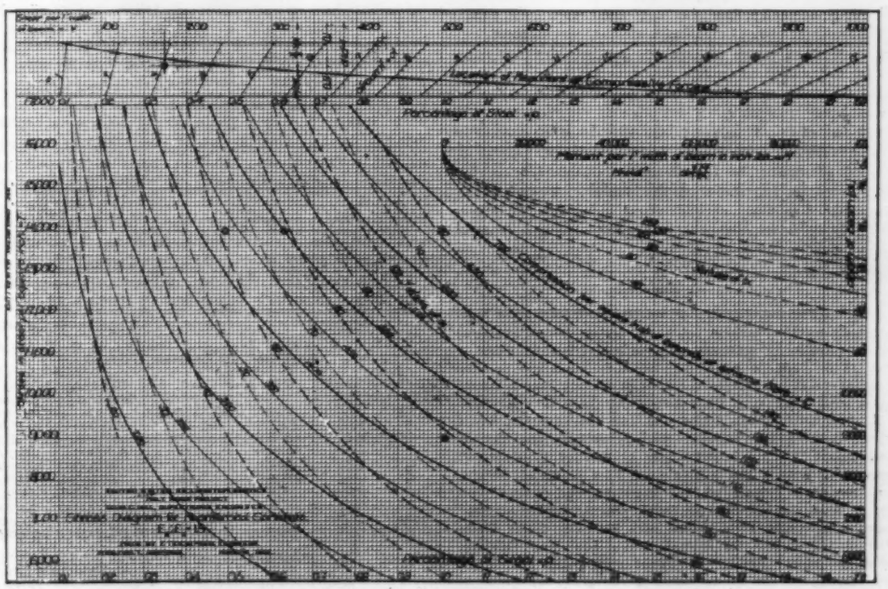


FIG. 3. DIAGRAM FOR REINFORCED CONCRETE BEAMS FOR $\frac{Es}{Ec} = 15$.

F. Teichman, Roosevelt, Arizona.

To vary the example, suppose, for the same floor, we retain the depth of beam (11 ins.), i. e., retain $a = 78.2$, but use better concrete, permitting $C = 500$, then the diagram gives the associated values $T = 14{,}000$, $p = 0.63$, so that the steel area is $F = 0.63 \times 11 \div 100 = 0.069$ sq. ins. per inch width. This means we save steel (0.069% against 0.111%), but have to have better concrete and must permit a higher steel stress.

If the floor is to be built as a slab-and-beam-floor instead of as a slab, the beams may be figured as T-beams. If we space the beams 6 ft. 6 ins. on centers, then by the German rule above quoted the compression width of the beam is one-third the effective span or ⅓ × 18.5 × 12 = 74 ins. The bending-moment per inch width is 9,412 × 78 ÷ 74 = 9,921 in.-lbs. The total end shear per beam is 165 × 78 = 12,870 lbs. The shear per inch width is 12,870 ÷ 74 = 174 lbs. Assuming $C = 433$, $T = 14{,}000$, and $E_s \div E_c = 15$ (Fig. 3), we find $p = 0.49\%$ and $a = 61.3$. The moment diagram now gives, for $a = 61.3$ and $M = 9{,}921$, $d = 12.7$ ins. Then the area of steel per inch width is

$$F = 0.49 \times 12.7 \div 100 = 0.062 \text{ sq. ins.,}$$

and the total steel area for the beam is 0.062 × 74 = 4.6 sq. ins.

In the shear diagram we follow the vertical through $p = 0.49$ to the curve, thence horizontally to $V = 174$, and find the value (circf. $\times$ d) = 3. Then the maximum allowable diameter of round bars, if all bars in the beam run through to the supports, is

$$D = \frac{0.49 \times 12.7 \times 12.7}{25 \times 3} = 1.05 \text{ ins.}$$

Using 1-in. round bars, 0.785 sq. ins. area each, we need 4.6 ÷ 0.785 = 5.85, say 6 bars. The tension width of the beam, for unit shear of 70 lbs. per sq. in., should be, by formula (8),

$$12{,}870 \div (70 \times 0.89 \times 12.7) = 16.25 \text{ ins.}$$

If instead of using 1-in. bars we use ¼-in. bars, we will need 4 × 6 = 24 bars. Twelve of these we run through to the supports. Six of the remaining twelve we may run as far as where the moment equals ½ × 9,921, i. e., for about ¾ the length of span, and the other six only as far as where the moment is reduced to ¾ × 9,921.

The slab running crosswise over these beams is to be figured in the same way as above shown for a slab floor, except that continuity may be considered. In order not to invalidate the calculation of the beam the slab must have a thickness at least equal to $3d\left(\frac{x/3}{d}\right)$. The diagram gives $\frac{x/3}{d}$ for $p = 0.49$ as 0.107. Therefore the slab should have a thickness equal to or greater than $3 \times 12.7 \times 0.107 = 4.08$ ins.

In the above diagrams of Mr. Teichman, the limiting concrete stress must be found on a curve, and in case of an odd figure it must be interpolated between two curves. It happens that usually the concrete stress is one of the data of a problem in either design or analysis of a reinforced-concrete beam, and on this account a diagram is more convenient for use if plotted so that the concrete stress forms one of the coordinates and can be set off directly on the graduations of the diagram. This arrangement is exhibited in a diagram sent us by Mr. E. J. Coppage, of Birmingham, Ala., and reproduced here as Fig. 4. The diagram is plotted on

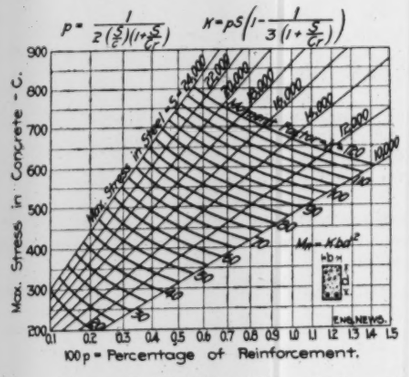


Fig. 4. Diagram for Reinforced Concrete Beams for $\frac{Es}{Ec} = 15$.

E. J. Coppage, Birmingham, Ala.

abcissas of variable spacing, so as to convert the curved lines of steel stress into straight lines. The curves for bending-moment coefficient remain curved lines, of course, as they do not vary with C according to the same equation as does p. The manner of using the diagram is the same as explained for Mr. Teichman's diagrams. No moment curve is given; but this is a very minor inconvenience, as even with such a curve it would generally be found more convenient to use the formula in place of the curve. There is no diagram for bond-stress, such as given in Figs. 1 to 3. The formulas above given by Mr. Teichman may, of course, be used to find the limiting size of bars.

PER DIEM CHARGES ON FREIGHT CARS have been changed by the various railways, acting under approval of the American Railway Association, from 25 cents a day to 50 cents a day. At the same time the penalty rate of $1 a day formerly charged on all cars retained by a road other than their owner for more than 30 days has been entirely abolished and the rate hereafter will be 50 cents a day whether the car is kept one day or two months. This increase has occasioned considerable opposition among the railways of New England, where, on account of certain traffic conditions, the expenditures for hire of foreign cars annually reaches many millions over the income from home cars used by other lines. The loaded freight car mileage going into New England averages about 75% in excess of that going out, while the empty mileage going out is three times as great as that coming in; that is, more freight goes into New England by rail than comes out by the same means. It does not necessarily follow that earnings on freight outbound from New England are less than on inbound freight, for much that goes into New England as raw products comes out as manufactured articles, upon which a higher rate is paid. It is estimated, however, that this increase will add close to $600,000 per annum to the expenditures of both the Boston & Maine and the New York, New Haven & Hartford Railroads.

CONCRETE T-BEAM AND COLUMN TESTS AT THE UNIVERSITY OF ILLINOIS.

The University of Illinois has recently completed a series of tests on reinforced concrete T-beams and also on concrete columns, both longitudinally reinforced and plain. The results of these experiments, together with much theoretical addenda, have been embodied in Bulletins Nos. 10 and 12 of the Engineeering Experiment Station of the university. The entire investigations are much too lengthy to give in the space which can be allowed here, but a resumé of the work done and an abstract of the conclusions arrived at by Prof Talbot, who had the test in charge, will be presented.

TESTS OF REINFORCED CONCRETE T-BEAMS.

The larger percentage of beams now used in reinforced-concrete construction are in floor-systems and joined to the slab in such intimate connection as to make the exact limits of the beam and slabs rather hard to define. As a result the effect of the slab in the design of the beam has been indeterminate and fixed by various standards in an arbitrary manner. The tests here outlined were made on beams with varying proportions of slab-width to beam-width and the effect in each case noted. The second object of the investigations was a determination of the efficacy of vertical reinforcing stirrups in resisting web-stresses. This latter is not an effect peculiarly applicable to T-beams alone, but as the Bulletin says:

> The large amount of reinforcement which may be put into a T-beam without encroaching on the compressive strength of the concrete too far and the resulting high web stresses developed in the stem of the T-beam, make the T-beam an advantageous form of test piece for determining the efficacy of various forms and amounts of web reinforcement.

In Fig. 1 the different kinds of beams used are shown. The numbers there given each beam are used throughout the discussion and in the tables. The stone was a good quality of hard limestone, screened through a 1-in. and over a ¼-in. screen. It contained 45% to 50% voids and weighed 85 lbs. per cu. ft. The sand was of good quality, fairly clean, sharp and well graded, contained 28% voids and weighed 115 lbs. per cu. ft. The cement used was furnished by the Joint Committee on Concrete and Reinforced Concrete, and was made up of a selected mixture of fine standard American brands. The concrete was made in the proportions of 1:2:4 and hand mixed by skilled labor. All stirrup reinforcement was of Johnson bars; the longitudinal rods were of various styles as shown in Fig. 1. The average ultimate strength of the plain round rods was 58,200 lbs. per sq. in. and the yield point 38,300 lbs. per sq. in. The ¾-in. Johnson bars developed an average ultimate strength of 88,400 lbs. per sq. in., and a yield point of 53,800 lbs. per sq. in. Preliminary compression tests on short blocks and cylinders by the same batches from which the beams were made show good concrete.

In figuring the stresses induced in the steel and concrete which are given in Tables 1 and 2, Prof. Talbot assumes that horizontal stresses in the concrete are not to be considered and that a plane section before bending remains a plane section after bending. With these assumptions the ordinary formulas for rectangular beams may be made applicable to T-beams with a close degree of approximation by using for the available cross-section the rectangle including the flange and stem down to the centroid of reinforcing bars. If the flange of the T-beam were thick enough to extend down to or below the neutral axis, the part of the concrete not included in the inclosing rectangle would, by the assumptions quoted above, not affect the resistance of the beam to flexure. If the flange does not extend to the neutral axis, a part of the compression area assumed to exist for the inclosing rectangle is not available in the T-beam, but the portion so cut off has, by reason of its proximity to the neutral axis, a comparatively small influence upon the flexural action of the beam. The effect is so little that, within certain limits of proportions, the inclosing rectangle may be substituted for the T-section in determining the position of the neutral axis, the tensile stress in the reinforcement, the compressive stress in the most remote fiber of the concrete, and the resisting moment of the section.

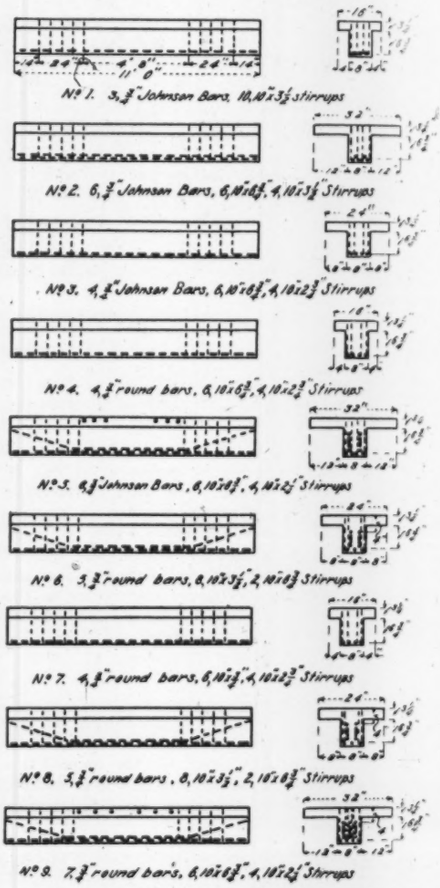

No 1. 3, ¾" Johnson Bars. 10, 10"x3½" stirrups
No 2. 6, ¾" Johnson Bars, 6, 10"x8½", 4, 10"x3½" Stirrups
No 3. 4, ¾" Johnson Bars, 6, 10"x8½", 4, 10"x2½" Stirrups
No 4. 4, ¾" round bars, 6, 10"x8½", 4, 10"x2½" Stirrups
No 5. 6, ¾" Johnson Bars, 6, 10"x8½", 4, 10"x2½" Stirrups
No 6. 3, ¾" round bars, 6, 10"x3½", 2, 10"x8½" Stirrups
No 7. 4, ¾" round bars, 6, 10"x8½", 4, 10"x2½" Stirrups
No 8. 5, ¾" round bars, 6, 10"x3½", 2, 10"x8½" Stirrups
No 9. 7, ¾" round bars, 6, 10"x8½", 4, 10"x2½" Stirrups

Fig. 1. Arrangement of Reinforcement, T-Beam Tests; University of Illinois.

For this approximation the formulas given by Prof. Talbot in his previous bulletins on rectangular beams will apply. That is

$$M = 0.86\ A\ f\ d'$$

where M = resisting moment at a given section
A = area of cross section of longitudinal reinforcement
f = tensile stress per unit of area in longitudinal reinforcement
d' = distance from longitudinal reinforcement to centroid of compressive stresses.

This equation is proved in Bulletin No. 4, University of Illinois Engineering Experiment Stations.

As the compressive area in a T-beam is so much in excess of a safe value, owing to the re-

TABLE I.—Results of Tests of T-Beams. $M = .86\ A\ f\ d$. All Failed by Tension in Steel.

Beam No.	Long. Reinforcement. Per cent.	Maximum Load, lbs. Total.	Per 8 ins. of Width.	Bending Moment, lb.-in.	Stress in Steel, lb. per sq. in.
1	1.05	46,700	23,350	923,000	64,300
4	1.10	32,410	16,200	631,000	41,500
7	1.10	30,100	15,050	579,000	38,100
3	0.93	55,700	18,570	1,107,500	57,500
6	0.92	39,300	13,100	773,500	40,700
8	0.92	40,100	13,370	783,500	41,200
2	1.05	80,500	20,120	1,608,000	55,700
5	1.05	83,300	20,820	1,658,000	57,400
9	0.97	50,900	12,720	1,004,000	37,600

TABLE II.—Web Stresses.

Beam No.	At First Diagonal Crack. Load in Lbs.	At First Diagonal Crack. v * lb. per sq. in.	At Maximum Load. Bond, lb. per sq. in.	At Maximum Load. Shear, v* lb per sq. in.
1	22,200	161	302	340
4	32,100	234	200	236
7	20,200	147	186	219
3	30,500	222	270	405
6	22,500	164	194	286
8	29,500	214	198	292
2	38,800	282	260	585
5	37,800	275	269	605
9	34,800	253	180	370

*v = vertical shearing stress and horizontal shearing stress per unit of area in the concrete.

culiar shape, the compressive stresses in the beams were not computed. Failure did not occur in the flange until after the steel had failed in tension.

The web stresses and bond between steel and concrete are also computed by Prof. Talbot's methods as given in previous bulletins. According to this theory

$$u = \frac{V}{mod'}$$

Where u is the bond stress developed, V is the total external vertical shear, m is the number of reinforcing bars, o is the effective circumference or periphery of one bar and d' is the same as above. For most conditions $d' = 0.86\ d$ where d = depth from top of beam to center of reinforcement. For the value of u, which equals either the horizontal or the vertical shearing unit stress, the two being equal,

$$u = \frac{V}{b'\ d'}$$

and d' usually equals $0.86\ d$. This subject of diagonal stresses is further explained as follows:

The diagonal tension existing in the web may be resolved into horizontal and vertical components. Considering the longitudinal bars to be all horizontal, we may expect, when the bond resistance is sufficient, that the horizontal component will be taken by the longitudinal reinforcement. Considering that the test has passed the point where the concrete of the web resists the diagonal tension, we may count that the whole vertical component of the web stresses is taken by the stirrups. The amount of this vertical component per unit of length of beam is for the T-beams equal to the horizontal shear for the width of the stem as given by equation (18), and $vb' = \frac{V}{d'}$ will give the rate of vertical stress per unit of length of beam which will go to the stirrups. If the stirrups are 6 ins. apart, the stress to be taken by the two prongs of the stirrup will be $6\ vb'$. This calculation is on the basis of a test loading which gives a constant shear from support to load point, as, for example, a loading at the one-third points. For a uniformly distributed load, the value vb' will be the rate of stress at a given section. To illustrate further: for a T-beam having a width of stem of 8 ins., and $d' = 8.6$ ins., and a load of 60,000 lbs., $V = 30{,}000$ lbs., and $v = 437$ lbs. per sq. in. With stirrups 6 ins. apart the total stress on one prong of the stirrup will be 10,500 lbs. These calculations do not take into account the resistance to bending of the reinforcing bars themselves. In the T-beams having also a part of the bars bent up, in order to avoid complicated calculations and to give a general comparison, the same formulas will be used herein, although the results are not an accurate measure of the stresses produced.

Integrity of Flanges.—In discussions on T-beams it is frequently stated that the thickness of the flange must be at least one half as great as the width of the stem or rib, in order that the shearing stresses at the junction of the flange and stem may not exceed those in the lower part of the stem. As the actual shearing stresses in both sections are well within the shearing strength of the concrete, there is no danger of failure by shear in either section, using the term shear in its strict sense. In the stem the shearing unit-stress is used as a measure or method of comparison for the diagonal tensile stresses. In the flange these stresses do not need consideration. Longitudinal shearing stresses in the flange, then, will not require consideration, and the limit of depth given above is unnecessary.

Another statement sometimes made is that the compressive stress in the flange varies across the width of the flange from a maximum amount next to the stem to zero at the edge of the flange. A little consideration will show that this cannot be true. The flange must transmit stress laterally to its edges, acting in a way as a beam with a load applied longitudinally and horizontally. The width of the overhang of the flange may be considered to be the span of this cantilever beam, and the distance from the load to the support (one-third the span length in the beams tested) may be thought of as the depth. Evidently this will be a very stiff beam, and the result will be a close approach to uniformity of compressive stress at points across the width of the flange. Little variation from a plane section may therefore be expected, the change that may exist being produced more largely by other causes. Of course there must be a limit to this assumed integrity of the cross-section, but for T-beams with the ordinary amount of reinforcement the compressive stress developed is small, and the variation may generally be neglected.

As usually constructed, the floor, and hence the flange of the T-beam, will have reinforcement at right angles to the stem. This will resist a breaking of the flange next to the stem and assist in giving the whole flange the curved shape which the beam takes when the load is applied.

The following is a summary of the conclusions reached by Prof. Talbot from the tests:

1. Beams of flange width of two, three, and four times the width of stem or web and reinforced in each case with steel equal to 1% of the inclosing rectangle exhibited in a common way the characteristics of rectangular beams, and the critical failure in every case came through the longitudinal reinforcement becoming stressed beyond its yield point.

2. The full compressive strength of the concrete at the most remote fiber was not developed at the yield point of the beam, even in the beams which were reinforced with steel of 54,000 lbs. per sq. in. yield point.

3. The beams with the wide flanges were deflected somewhat more than the narrower beams, as may be expected from the lack of full width of concrete on both the compression and the tension sides of the neutral axis, the deficiency affecting the stiffness of the beam but having little effect upon its strength at points of maximum bending moment.

4. The vertical stirrups used proved to be very effective web reinforcement. The diagonal tension cracks appeared at or above the loads at which failure by diagonal tension may be expected in beams without web reinforcement. A high resistance to diagonal tensile

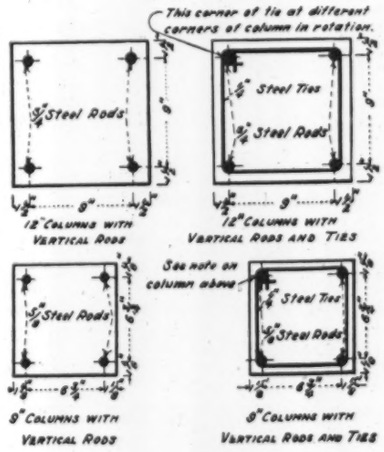

This corner of tie at different corners of column in rotation.
Steel Rods
Steel Ties
Steel Rods
12" Column with Vertical Rods
12" Column with Vertical Rods and Ties
See note on column above
Steel Rods
Steel Ties
Steel Rods
9" Column with Vertical Rods
9" Column with Vertical Rods and Ties

Fig. 2. Column Tests, University of Illinois. Arrangement of Reinforcement.

stresses was developed, as measured by the calculated maximum vertical shearing unit-stress, which in one beam was 605 lbs. per sq. in. Since no beam failed by diagonal tension, the limit of strength of the web reinforcement was not determined.

5. The observed phenomena of the tests give no indication of distortion from a plane cross section, and there was no indication that the thin flange was an element of weakness. The tearing of the flange of one beam after the maximum load was reached was due to causes which would not exist in a floor system as usually constructed. [Beam No. 2 failed by breaking of flanges] It seems clear that the limit of useful width of flange was not reached in the beams tested.

6. The maximum strength of T-beams to resist horizontal tension and compression (flange stresses) may well be calculated by using the ordinary methods and formulas in use for rectangular beams and considering the inclosing rectangle of the T-beam to be the equivalent rectangular beam. This approximation is at least applicable for reinforcement not exceeding 1% of the inclosing rectangle. It gives little error when the thickness of flange is at least one-quarter of the depth of beam and the width of flange not more than four times the width of stem, and may be used for an even greater range without great error. The inclusion of a greater width of flange than four times the width of stem would not materially change the calculated strength of the beam, since the amount of steel which may be put into the stem is usually limited by considerations which of themselves will hold the compressive stresses within proper limits, and since the moment arm of the horizontal couple will not change much with an increase in width of flange. The web stresses, which here are very important, will differ from those found for rectangular beams, and for T-beams the actual width of stem must be used in the calculations for vertical shear and diagonal tension.

TESTS OF CONCRETE AND REINFORCED CONCRETE COLUMNS.

The experiments treated in this bulletin were made as a preliminary series to the study of the whole subject of concrete columns; a study which will continue over several years work. The tests in this series were made only on plain columns and those reinforced with longitudinal rods; the larger division of hooped columns is to be taken up next year. The materials used in the test were practically the same as those noted above in the T-beam tests. Three types of specimens were made—(a) cubes, (b) cylinders and (c) columns, the concrete for all being in a 1:2:3¾ mixture. The cubes were made with 12-in. edges and the cylinders 8-in. diameter and 16-in. long; each out of the same batches as the corresponding column. Three series of columns were made, one set with no reinforcement, one reinforced with vertical rods only and one reinforced with vertical rods in the corners tied together with ties of ¼-in. rods every 12 ins. in height. The sizes and arrangement of reinforcement are shown in Table 3 and Fig. 2. The shortenings or longitudinal deformations of the columns were read by means of an extensometer so arranged as to indicate the deformation in the center of each face of the column.

TABLE III—SUMMARY OF COLUMN TESTS.

Col. No.	Nominal Size in. x in. x ft.	Area of Cross-section sq. in.	—Reinforcement— Kind	Per cent.	Age days.	—Maximum Load— Total pounds.	lb. per sq. in. Concrete alone.	lb. per sq. in. Gross section.	Initial modulus of elasticity lbs. per sq. in.	Manner of failure.
1	12x12x12	147.4	4—⅜-in. rods.	1.20	71	234,000	1,220	1,587	2,570,000	Crushed on one side 4 ft. from bottom
2	9x 9x12	80.6	4—⅜-in. rods	1.52	69	127,000	1,160	1,577	2,330,000	Crushed out near top
3	12x12x12	146.2	4—⅜-in. rods 12—¼-in. ties	1.21	71	272,000	1,380	1,862	2,340,000	Crushed out 1 ft. from bottom. Rods finally buckled
5	12x12x12	146.4	Plain	0.	69	250,200	....	1,710	3,150,000	Crushed and sheared diagonally, 1½ ft. below top
6	9x 9x12	80.9	4—⅜-in. rods	1.52	70	129,400	1,090	1,600	2,090,000	Crushed out 1 foot from bottom. Rods finally buckled
7	12x12x12	145.5	4—⅜-in. rods	1.21	65	269,000	1,400	1,850	2,570,000	Crushed and sheared 5 ft. from bottom
8	9x 9x12	80.8	Plain	0.	64	162,000	....	2,004	2,530,000	Top sheared off
9	12x12x12	146.6	Plain	0.	65	236,000	....	1,610	2,500,000	Crushed and sheared off at top
10	9x 9x12	82.0	4—⅜-in. rods 12—¼-in. ties	1.50	65	105,000	775	1,280	1,800,000	Crushed out 1 foot from bottom. Rods finally buckled
11	12x12x12	145.2	4—⅜-in. rods 12—¼-in. ties	1.21	65	281,200	1,460	1,936	2,480,000	Crushed 1½ ft. from top
12	9x 9x 9	82.7	4—⅜-in. rods 9—¼-in. ties	1.48	66	193,100	1,685	2,335	2,500,000	Crushed 1 ft. below top
13	12x12x12	148.8	Plain	0.	61	254,000	....	1,709	2,370,000	Crushed in middle of length
14	9x 9x12	82.0	4—⅜-in. rods 12—¼-in. ties	1.50	63	113,000	955	1,367	2,000,000	Crushed 1½ ft. below top
15	12x12x 6	148.0	Plain	0.	63	176,000	....	1,189	2,000,000	Crushed 1 ft. from top
16	9x 9x 9	82.5	4—⅜-in. rods 9—¼-in. ties	1.49	59	131,500	990	1,607	1,900,000	Crushed at center Rods finally buckled
17	9x 9x 6	83.6	4—⅜-in. rods	1.47	67	184,400	1560	2,206	1,900,000	Crushed 1ft. from top Rods finally buckled
18	9x 9x 6	83.6	Plain	0.	63	90,300	....	1,079	1,490,000	Crushed 1 ft. below top

Tests made on the curves and cylinders show the following strength in compression:

		Lbs. per sq. in.
Cubes:	Average of 16 specimens	2,100
	Maximum	2,672
	Minimum	1,472
Cylinders:	Average of 8 specimens	1,490
	Maximum	2,088
	Minimum	1,068

The summary of the column tests is noted in Table 3. In the analysis from which the various unit values in Table 3 are found and which form the basis of the summary of deductions at the end of this article, the following scheme has been used:

Fig. 3 represents a typical stress-deformation diagram for a reinforced column in which the abscissas are proportional deformations and the ordinates unit loads. The curve marked "Line for Concrete and Steel" is a theoretical parabola that Prof. Talbot has computed and which closely approximates the true deformation curve of the column. The line marked "Line for Steel" represents for any given deformation the load per square inch considered distributed over the area of the column which is equivalent to that taken by the steel alone, considering the modulus of elasticity of the steel to be 30,000,000 lbs. per sq. in. Thus, for a deformation in the column of .001, the corresponding stress in the steel is 30,000 lb. per sq. in. For a column having steel reinforcement equal to 1½% of its cross section, the load thus taken by the steel is equivalent to 450 lb. per sq. in. distributed over the whole cross section, and the "Line for Steel" is drawn through 450 lb. per sq. in. and a unit deformation of .001. For any given deformation, then, the amount of load below this line represents, on this basis, the part taken by steel reinforcement, and the amount above this line represents the part taken by the concrete. The line OD is the line of stress deformation for concrete alone and is obtained by subtracting the ordinates for the "Line for Steel" from those for the "Line for Steel and Concrete." The lines OA and OB represent the initial moduli of elasticity for steel and concrete and for concrete, respectively, and are tangents to the parabolic curves at the origin. Prof. Talbot proves that the maximum stress in the concrete comes at a point where a parallel to the "Line for Steel" is tangent to the "Line for Concrete Alone." Beyond this point, while the column as a whole may sustain a larger load, a greater proportion of this load is taken by the steel, and the concrete has passed its maximum carrying capacity. From the deformation-stress conditions at this point unit stresses may be computed. Values so found are given in Table 3.

The Bulletin further explains the use of this diagram as follows:

The Parabolic Stress-Deformation Relation.—To begin with, it may be premised that a study and analysis of the relation between the stress or load in pounds per square inch and the unit deformation or shortening of the concrete will be of considerable value in the discussion and interpretation of the phenomena of compression of concrete in plain and reinforced columns. This stress-deformation relation has an important bearing upon the strength of columns and on the proportion of load taken by the concrete and by the steel reinforcement in reinforced concrete columns. An analysis based on a curved stress-deformation relation, although not difficult, requires some little explanation. It is hoped, therefore, that the reader will go over the discussion fully with the applicability of such an analysis in mind and not hastily conclude that undue weight has been attached to the curved form of the stress-deformation relation. Nor should the reader consider that the use of the parabolic relation in this discussion commits the writer to the position of excluding the straight-line stress-deformation relation (constant modulus of elasticity) from use in any formulas or applications whatever.

In a general way it may be said that concrete does not possess the property of proportionality of stress and deformation for wide ranges of stress as does steel; in other words, the deformation or shortening produced by a load is not proportional to the compressive stress. The relation between stress and deformation is not entirely uniform; there are even considerable differences in deformations for the same mixture, but generally the variation from direct proportionality is less for the richer mixtures. Various curves have been proposed to represent the stress-deformation relation, but the parabola is the most satisfactory general representation. Frequently the parabola expresses the relation almost exactly, especially for mixtures of medium richness, and in nearly every case the parabolic relation will fit the stress-deformation diagram very closely throughout the part which is ordinarily developed in columns, the lack of agreement near the crushing point not being so important.

Modulus of elasticity is a term which has been used very loosely in connection with reinforced concrete. As a general property of materials, it is defined to be the ratio of the unit stress to the unit deformation within the elastic limit of the material. As applied in this way to materials having the property of proportionality of stress and deformation, the modulus of elasticity is a constant. For materials with a variable stress-deformation relation like concrete it may not be considered proper to call the variable ratio the modulus of elasticity, and such a use may lead to misunderstanding. However, it is important that a definite expression for this ratio be found.

The writer obtains this relation from the initial modulus of elasticity, and uses the term "Initial Modulus of Elasticity" to express the relation which would exist between stress and deformation if the concrete compressed uniformly at the rate it compresses when the load is first applied. For the parabolic stress-deformation relation, the line which represents this uniform or constant stress-deformation relation will be tangent to the parabola at the zero point.

The Bulletin also gives a resumé of some similar tests made at Watertown Arsenal and

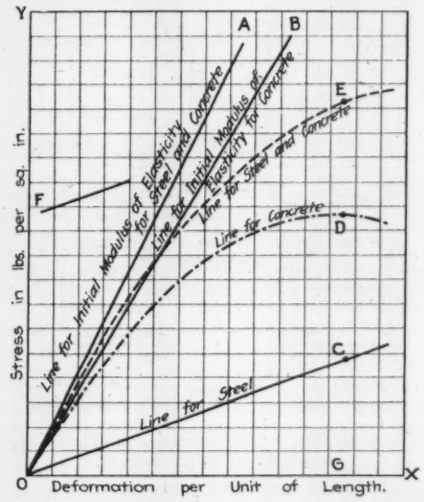


Fig. 3. Stress Deformation Diagram for a Reinforced Concrete Column.

these tests are analyzed after the methods outlined above. The results agree for the most part with the present tests.

COLUMNS IN BUILDING CONSTRUCTION.

In view of the current discussion on the working stresses to be used in reinforced concrete columns the following paragraphs on this subject should be of interest:

Discussion of Columns in Building Construction.—It may be well to call attention to some of the reasons why columns may be a weak point in reinforced concrete construction, and to offer a word of caution concerning their construction. The conditions of column construction as ordinarily carried on in building operations give little chance for efficient inspection, and there is abundant opportunity for great variation in the concrete, since the work is out of sight and the mixture of the material and the tamping or stirring will be far from uniform, much less uniform than in the test columns herein described. Even in test columns the poorer columns carried low ultimate loads. If, in addition to these considerations, the possible uneven distribution of the assumed load due to settlement, shrinkage, and uneven stiffness of the floor system be also taken into account, the need for using low working stresses and careful construction ought to be apparent. Evidently a fairly rich concrete made of a high grade of cement should be used. It is not improbable that in many buildings the working stresses used are too high for the concrete actually put into the columns. Besides, it must always be borne in mind that the strength obtained from test cubes may not be taken as representing the strength of a column. It is probable that many engineers have been misled by high values obtained on test cubes. Again, great caution should be used in the time allowance for removing the forms, particularly in cool weather, for the concrete in the columns should be fairly well set before much of a load is allowed on it. A method of construction should be selected which will not bring weight upon the columns until the forms are removed, and the concrete is thoroughly set. It is fortunate that the concrete continues to gain in strength for a considerable time, although this advantage is counteracted in a structure to some extent by the injury to the concrete caused by early application of the load.

Both plain and reinforced concrete columns take up considerable room, particularly on the lower floors of a building. A richer concrete will permit a reduction in the area occupied. The large size of the columns makes the effect of eccentricity of loading smaller than it would be otherwise. Columns of hooped concrete have been used as a means of reducing the cross-section. It is hoped that the investigation of hooped columns now in progress at the University of Illinois will throw some light on this allied subject.

SUMMARY.—The following summary of the column tests is made by Prof. Talbot:

1. In discussions involving the strength and stiffness of concrete, the variability of the concrete must be taken into consideration. Test columns made with care to secure uniformity of conditions show considerable diversity in quality. An even greater variation in character must be expected under the conditions of ordinary building construction.

2. Cubes and other small test specimens are made under conditions which give a stronger and denser concrete than is generally found in full-sized pieces in building work. The restraining effect of the bearing plates of the testing machine also influences the results of cube tests. It is evident that the test pieces used in many tests recorded in engineering publications were made with a quality of materials, methods of fabrication, and conditions of setting which are far more favorable to high results than will be found under average conditions of construction. Caution should therefore be used in accepting as a basis for design values obtained from tests without knowing fully all the conditions accompanying the investigation.

3. The relative amount of load taken by the concrete and by the steel, in columns with longitudinal reinforcement, may be determined by means of the observed relation between loads and deformations under the assumption that the stress in the steel reinforcement is proportional to the deformation in the column. It is assumed that the bond between the steel and the concrete is adequate. This method forms an efficient means for discussing the relative stresses in steel and concrete.

4. By the method of analysis used, the average maximum stress in the concrete for the reinforced columns tested is found to be 15% less than the average for the plain concrete columns. While this may not be taken as a final or representative conclusion, since it may be merely incidental to the columns used or the method of testing, it is at least an added reason for caution in choosing working stresses for this form of construction. The average total load taken by the reinforced columns, it should be understood, was considerably higher than the average for the unreinforced columns.

5. The plotted diagrams representing the loads or stresses in the columns, and the corresponding deformations or shortenings (stress-deformation diagrams), show a variable relation which is well expressed by the parabola. The tangent to the parabola at the point of zero load represents by its slope the initial modulus of elasticity of the concrete, and forms a convenient basis for an expression for the variable relation between stress and deformation. It should not be inferred that this relation is generally applicable to very rich or very lean concrete.

6. Gross (total) deformations and not net (elastic) deformations are used, since in the application of the stress-deformation relation to columns and beams gross deformations will, under the hypotheses ordinarily accepted, enable the stress in the steel to be determined, and net values will not.

7. The fact that during the operation of releasing a load the stress-deformation diagram does not follow the parabola, but takes a course which approximates a straight line, is not a valid reason for not accepting the parabolic relation in the analysis of beam and column action. When a beam has been loaded up to a given load, the area of the part of a section above the neutral axis is in compression, and no point of this section has been strained beyond the amount then developed at that point, each point having the highest stress which has come upon it. The effect of repeating a load on a beam in progressively increasing amounts is to increase all the deformations in the section, but the resulting curve will still resemble the parabola, and the resulting initial modulus of elasticity will have a smaller value than that found for the first application of load.

8. The Watertown Arsenal tests of columns of composition similar to the University of Illinois columns are comparable in strength and stiffness and in the form of stress-deformation diagram, and tend to confirm the results and conclusions of the University of Illinois tests. The average maximum compressive stress taken by the

concrete in the Watertown Arsenal columns was 1,590 lbs. per sq. in. In the University of Illinois columns it was 1,550 lbs. per sq. in. for the plain columns and 1,290 lbs. per sq. in for the reinforced columns.

9. The average value of the initial modulus of elasticity given for the University of Illinois columns, 2,250,000 lbs. per sq. in., and that for the Watertown Arsenal columns, 2,500,000 lbs. per sq. in., may be considered tentative values for 1:2:4 concrete of the kind described for use at an age of 60 to 105 days and first application of load. Age will increase the modulus and repetition decrease it. What the combined effect of these two agencies will be is not known, but it will vary with the conditions of materials and number of repetitions and also with the age at which loads are first applied. When a constant modulus of elasticity (straight-line relation) is used, the value chosen should be less than that for the initial modulus here given. The high values of modulus of elasticity frequently quoted are doubtless due to shortness of length of test piece, high quality in the test pieces used, use of elastic deformation, etc. The quality of the aggregate, as well as of the cement used in making test pieces, may not always be representative of that used in building operations.

10. The proper basis for working factor and working stress for use in designing with any given material and form of construction is of much more importance than is usually given to it. The conditions of loading, of transmission and distribution of load, of variation in fabrication and construction, all act to make the stress actually developed in a member of a structure greater than the assumed working stress. For steel the real basic point is the elastic limit or yield point. For concrete this basic point may well be considerably below its ultimate strength. The choice of a value corresponding to a deformation equal to one-half of the deformation at point of failure is suggested. This, by the parabolic relation, is equal to three-fourths of the ultimate strength. Having selected a basic point, a working factor to obtain the working stress will then be chosen to cover contingencies and emergencies and the variations in distribution of load, quality of materials, method of fabrication, nature of load and its manner of appplication, etc. The range in the values for the working factor which may be used under the various conditions of repetition of load, workmanship and material, is of course much greater with concrete than will be necessary with such a material as mild steel.

11. The ratio between the amount of stress taken by the steel and that taken by the concrete in columns reinforced with longitudinal rods varies as the load is increased, as may be expected from the variable stress-deformation relation of the concrete. In these tests this ratio varied from 12 at the initial application of the load in one column to 34 at the maximum strength of the concrete in another. For the average initial modulus of elasticity of the concrete, the range is from 13½ at the zero load to 26⅔ at the ultimate. For very rich concrete the effect of the additional stiffness and the lower final deformation is to decrease this ratio, and for lean concrete the smaller modulus and greater final deformation will make it larger.

12. If we choose the half-way deformation for our basic point, the value for the ratio of stress in steel to stress in concrete may, from the two sets of experiments, be taken as 17 to 18 for 1:2:4 concrete of the quality used in the tests. However, this ratio may properly be taken to be even higher than an average value, since for columns weaker than the average column the ratio may be expected to be higher than the average value, and hence to fit the conditions of such columns better, while for columns stronger than the average the added strength of the concrete will go to make up for the overestimated stress in the steel. For this assumption, 18 to 21 may be used.

13. Under the conditions of building construction, columns may form a weak element in the structure. To overcome this, the working stresses should be kept low and every precaution taken to secure proper materials, workmanlike fabrication, and efficient inspection.

WORKING STRESSES AND WORKING FACTOR OF SAFETY IN STRUCTURES.

In our issue of Sept. 6, 1906, we published an editorial upon the so-called Factor of Safety in Structural Design. A somewhat similar discussion has recently appeared in Bulletin No. 10 of the Engineering Experiment Station of the University of Illinois in Prof. A. N. Talbot's resumé of Tests of Concrete and Reinforced Concrete Columns.

As this particular portion of the Bulletin has a wide application of current interest to engineers in general, it is republished here instead of in the abstract of the tests which is given elsewhere in this issue:

The real basis for a working stress or a factor of safety to be used in designing seems not to be generally understood, or at least it is not often properly explained, and expressions sometimes heard indicate that the purpose and use of factor of safety and working stress are misinterpreted. Of course, no engineer will say that for a factor of safety of, say, four (using the term factor of safety as based upon the ultimate strength of the material) the structure will take four times the assumed load without injury. It is understood by engineers that the actual ratio of the load which the structure may properly take under the ordinary conditions of construction to the assumed load used in the calculations made in the design is not large and may, under some circumstances, not be very much above one. Yet the statement is sometimes made, or the inference may be drawn, that because a given working stress is to be used in the calculations there is no advantage in looking into the behavior of the material or the action of the structure at a stress higher than the assumed working stress. It may, therefore, be well to consider some of the aspects of working stresses and factors of safety.

Mild steel has a rather definite elastic limit and yield point beyond which the character of its action changes in a marked way. Beyond the yield point the rate of stretch in tension becomes almost at once one hundred or more times as much as it was within the elastic limit. In compression, the ultimate strength of mild steel is not far beyond its elastic limit. It is evident that a structure made up of this material will distort and fail when a load producing stresses not much greater than the elastic limit is placed upon it. The elastic limit of mild steel has a small range, its value running from 50% to 65% of the ultimate strength, depending upon the size of the piece, method of rolling, etc., and the steel is made under such conditions that little risk is taken in choosing a value for a particular size and shape of piece. The modulus of elasticity of steel is also quite uniform. It may be said then, that the properties of this material, with proper inspection, are fairly definitely known. When we base the factor of safety of a structure upon ultimate strength of mild steel, whether we do it consciously or unconsciously we have tacitly assumed that the factor of safety named in the calculations is nearly double the factor which will bring actual failure under the conditions assumed to exist in the structure.

For a plastic material, or a material not having a definite elastic limit, or at any rate one for which the stress varies directly as the deformation for at best only a small part of the ultimate strength of the material, a different consideration must be given. For such materials, the effect of lack of uniformity of the material, the effect of increased deformation, of repetitive loading, of time, and of other factors must be considered.

But there are other considerations which go to confine the working stress, particularly in concrete, to the low value usually assumed. Sometimes the stress is made low to allow for a possibly greater load than that assumed, or for a load applied other than statically. Even if the assumed load has the correct total amount, the following items may be said to influence the choice of a lower working stress: (1) Uneven distribution of load among members; (2) Unconsidered stresses due to settling, variability of the material, etc.; and (3) Variation in the material and in its fabrication.

(1) Even with a load of the amount assumed, the division of this load among the members of the structure may be uneven. Variations in stiffness, differences in quality of adjacent members due to inherent variations or to the variations which arise in such a material as concrete during fabrication and setting, differences due to restraint or lack of restraint at connections—all go to make the actual distribution of the load different from its assumed division among the members. In a timber trestle bridge, the weaker stringer is generally less stiff than its stronger neighbor, and hence the poor stringer takes a smaller share of the load and the good one a greater. Even in steel building construction, differences in rigidity of connections, modifications made to overcome lack of exact fit, and variations caused by field riveting act to modify the division of the load. In concrete construction the variations in fabrication and conditions of setting (e. g., in the beams and girders) and the consequent variable effect on stiffness and restraint may have a considerable effect upon the division of the load. This is especially true in the floor, beams, and girders, so that the load transmitted to a particular column may be quite different from that assumed.

(2) Settling of the foundation of one column more than of another is possible. A variation in the shrinkage of adjacent columns through variation in conditions attending fabrication or to a less extent in porosity or stiffness of column will modify the distribution of the load. Variations in size also affect this distribution. The more nearly uniform the dimensions and physical properties, the more nearly regular the division of load will be and the higher the allowable comparative working stress. In this respect, steel is an advantageous building material.

(3) The values of physical properties usually quoted are average values. The data were obtained from test pieces, sometimes large, frequently small, and these may be said to have been made and tested under favorable conditions. Since the members of a structure which have the poorest quality may have a controlling influence upon the amount of load to be carried, if average values are used the factor must be greater to allow for this. In other words, in poorly made beams or columns the load or stress which comes on the piece is relatively nearer the point of failure than is indicated by the use of the assumed working stress and an average ultimate value.

Enough has been said to show that the assumed stresses are not the actual stresses coming upon the members of a structure and that the relation between the assumed working stress and the average ultimate strength of the material is a matter which should involve thought and study. It may then be stated that (a) the stress actually brought upon a member of a structure by an assumed loading may be materially higher than the assumed working stress, and (b) the stress actually developed in a member may be much higher comparatively (i. e., with respect to its own ultimate strength) than even this increased amount would indicate. This goes to show that the nature of the action of the material, including its stress-deformation relation, should be studied at points well above the assumed working stress. What point should be fixed upon as a basic point, upon which a working factor covering uneven distribution of load, uncertainty of quality, effect of repetitive loading, etc., may be based, will depend upon the nature of the material and the condition of the structure.

TESTS OF PERRY'S THEORY OF BOILER EFFICIENCY

The government fuel-testing plant at St. Louis, Mo., took up about a year ago in its boiler division a line of experiments to prove or disprove the mathematical conclusions of Prof. John Perry, Past President Institution of Electrical Engineers, which were set forth tentatively in his book, "Steam Engines and Gas and Oil Engines."

Prof. Perry's theory states that all modifying conditions of the boiler design being the same, or being eliminated, any boiler will absorb by convection from the hot gases passing through it a given percentage of heat for a given steam temperature. This efficiency is, therefore, independent of the temperature of the entering gases and of the amount of gases blowing through the boiler. It is understood that this statement of Perry's theory is subject to slight theoretical and much larger practical modifications.

For example, by this theory, if a boiler has an efficiency of 70%, with gases entering the boiler at 1,300° F., then this particular boiler will still have an efficiency of 70% if the gases enter at 2,000° F. It will be seen that the volume of gases does not enter into consideration.

This mathematical deduction of Perry is being practically investigated by this section of the Geological Survey. A progress bulletin recently issued states that it has been found when keeping other conditions the same and when keeping the initial temperature of the gases constant, that the final temperature of the gases remains the same at whatever rate the gases are sent through the boiler. The upper limit of this phenomenon has not been found, with tubes clean inside and out, although the rate of evaporation has been pushed to several times that common in locomotive boilers.

Perry's theory takes into account four fundamental conditions of the gases in boilers affecting heat absorption at any point of the heating surface: (1) Temperature difference between the gases outside any portion of the boiler tube and the water inside; (2) the number of molecules per cubic inch in the gases outside the boiler tube; (3) the specific heat of the gases at constant pressure; (4) the velocity of the gases parallel to the heating surface. Of these four factors, the first has usually been the only one considered. It will be seen, however, that as the temperature of the gases is increased, the number of molecules beating against a square inch of heating surface is decreased and that, therefore, the second factor tends to neutralize the effect of the first, especially at a high gas temperature.

The third may be assumed according to this preliminary paper, for practical conditions, at 0.24. It would seem probable that this value included the work of expansion which would reduce the proper value to about 0.18. Doubtless this will be explained when the more complete report appears.

The last factor is a new one. Prof. Perry considers that gases traveling at a high velocity, parallel to the heating surfaces, scrub off, considerably, the film of cooler and denser gases adhering to the metal. According to this theory, the greater the velocity, the more effective the scrubbing and the greater the amounts of heat absorbed by the metal. This assumes an unlimited ability of the metal to so transmit heat and as ordinarily a boiler is so designed that the metal transmits only about 1/1000 its capacity, Prof. Perry thinks this assumption warranted. The experiments carried on are claimed to check the Perry theory closely.

These experiments have been conducted by Mr. Walter T. Ray, Assistant Engineer, under the supervision of Prof. L. P. Breckenridge, M. Am. Soc. M. E., Engineer in Charge of the Boiler Division, Fuel Testing Branch, U. S. Geological Survey.

A more detailed statement of the theory and of the results of the experiments will be published in a special bulletin in two or three months. Until that appears detailed criticism is hardly worth while; but so far as at present appears practical boiler design and operation are hardly likely to be affected by the final conclusions.

COAL AND COKE HANDLING AT THE ASTORIA LIGHT, HEAT & POWER CO.'S PLANT, ASTORIA, L. I.

By ALFRED KAUFFMANN.*

In giving a description of this installation, we shall consider the machinery at the north and south ends of one retort house only—the houses being practically duplicates—and shall follow the coal from the time it is unloaded from the cars until it is loaded again as coke, giving a general description of the machinery necessary for its transportation.

Owing to the location of the plant, the coal is ordinarily brought to the site by water; it is transferred to the retort houses, which are about a quarter of a mile inland, by railway cars. A bucket of one ton capacity, operated by a revolving locomotive crane, removes the coal from the barges and discharges it into the cars.

The general arrangement of the plant is shown in Figs. 1 and 2. The coal, mostly run-of-mine bituminous, is discharged from hopper bottom railway cars into 10 × 12-ft. steel track hoppers, and is fed automatically to conveyors which carry it to the crushers in the tower. From the crushers it passes through the disintegrators for further reduction in size and is then fed to the elevators and raised to belt conveyors running above the main storage bin in the retort house. From the bins it is fed into the retorts. The coke drawn from the retorts is carried by conveyors to either end of the retort house, is quenched, and discharged into carriers encircling the storage bins.

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The appliances used in handling the coal and coke are in detail as follows:

TRACK HOPPERS AND RECIPROCATING FEEDERS.

There are four steel hoppers, two for each conveyor. Each hopper is fitted with a reciprocating feeder, see Figs. 3 and 4, the duty of which is automatically to feed the proper load to the conveyors. The rate of feed depends upon the stroke of the feeder plate, and can be varied by changing the throw of its driving eccentric; the latter is an adjustable eccentric, i. e., one eccentric within another, thus making it an easy matter to control the amount of material delivered to the conveyor. Each feeder, when set for 7 in. stroke, has a capacity of about 125 tons per hour, and the two are so arranged with friction clutches that they may be run either singly or together as desired. A 7½-HP. alternating current motor drives both feeders. The feeder not only dispenses with the labor of a man, but prevents overloading the conveyor and consequent dangers.

CONVEYORS.

Two conveyors carry the coal from the hoppers to the crushers. They are of the pusher type, the coal being moved along a steel lined trough by steel flights attached at intervals of 36 ins. to two strands of steel-bushed strap chain fitted with rollers. Each conveyor is gear driven by a 25 HP. alternating current motor and has a capacity of 125 tons per hour at a speed of 100 ft. per minute.

A special feature in connection with the driving machinery is the use of a safety device in the form of a break pin hub. The gear, meshing with the motor pinion instead of being keyed to the shaft as in most cases, runs loose, and a driving hub is keyed to the shaft instead. This hub is connected to the driven wheel by a necked pin, the extent of reduction at the neck of the [illegible] being determined by the amount of power [illegible] transmitted; therefore any unusual strain in [illegible] conveyor results in breaking the pin, leaving [illegible] driven wheel free to run and stopping the [illegible] veyor, accordingly preventing an accident. [illegible] 5 shows a modification of this device applied [illegible] a sprocket wheel instead of to a gear.

CRUSHERS AND DISINTEGRATORS.

There are two crushers and two disintegrators, each of the two roll type as shown in Figs. 6 and 7. The crusher rolls are 28 ins. in diam. and 36 ins. long, with coarse chilled teeth; they run at a speed of 100 r. p. m. Each crusher will reduce run-of-mine bituminous coal to 2½ ins. and under at the rate of 125 tons per hour. The disintegrator rolls are 48 ins. in diameter and 36 ins. long, with chilled ridges; they are geared to run at differential speeds of 125 and 250 r. p. m., respectively, and can be adjusted for a reduction to ½ in. and under. Both machines are housed by ¼ in. steel hoods which fit closely to the cast iron frames, making them practically dust proof. Each crusher with its disintegrator is belt driven by a 35-HP. alternating current motor. The chute from the crusher to the disintegrator is provided with a by-pass gate allowing the coal to be fed directly to the elevator.

ELEVATORS.

Two elevators receive the coal from the disintegrators and elevate it to the belt conveyors. They are of the V bucket type, with buckets at intervals of 36 ins. on steel-bushed strap chain fitted with rollers. Each has a capacity of 125 tons per hour at a speed of 75 ft. per minute, and is gear driven by a 25-HP. alternating current motor. In connection with the driving machinery, a safety device is used similar to that on the flight con-

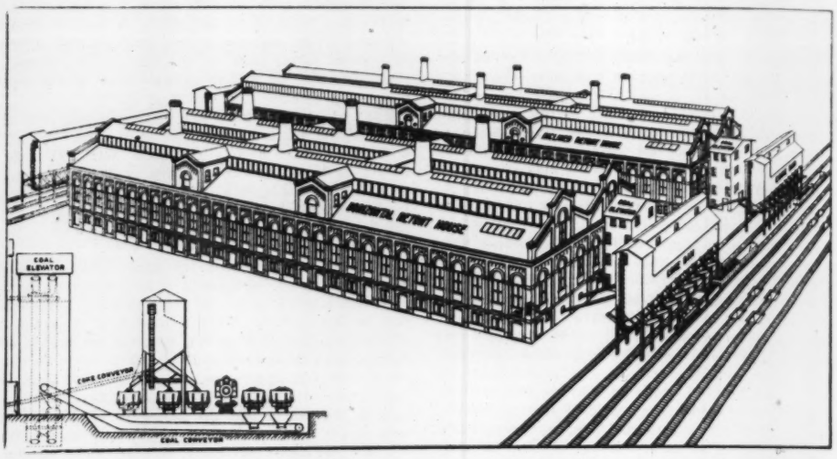


FIG. 1. RETORT HOUSES AT THE ASTORIA LIGHT, HEAT & POWER CO.'S PLANT; GENERAL PERSPECTIVE VIEW.

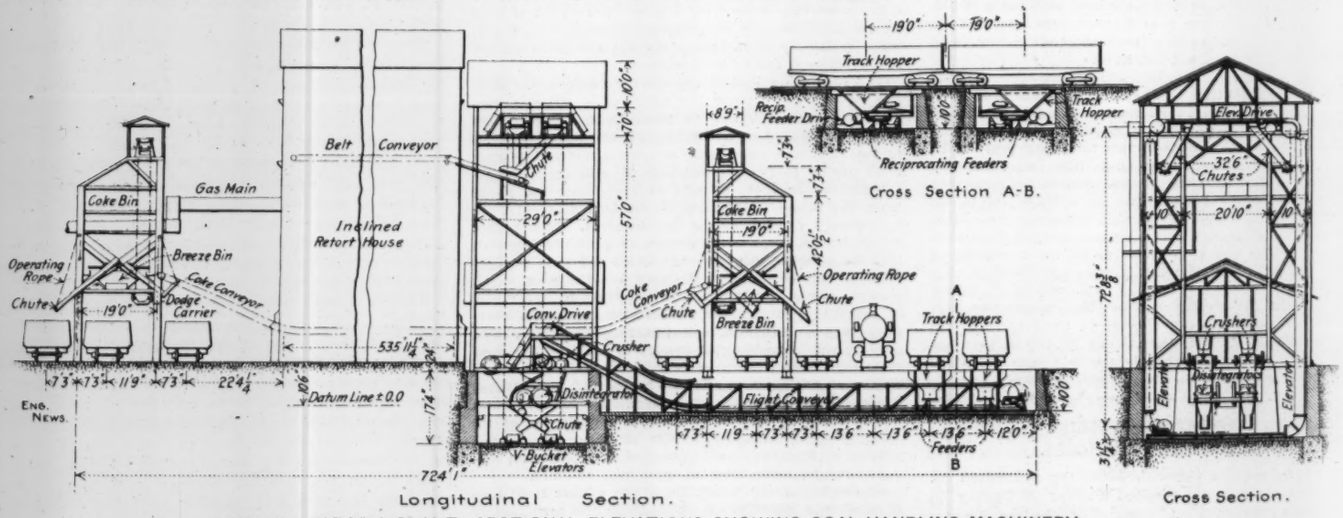


FIG. 2. ASTORIA PLANT; SECTIONAL ELEVATIONS SHOWING COAL-HANDLING MACHINERY.

veyor. A band brake 30 ins. in diameter is also used to prevent the machine from running backwards in case of the breaking of the chain. The vertical runs are enclosed in steel casings. The upper horizontal run of the elevator, which con-

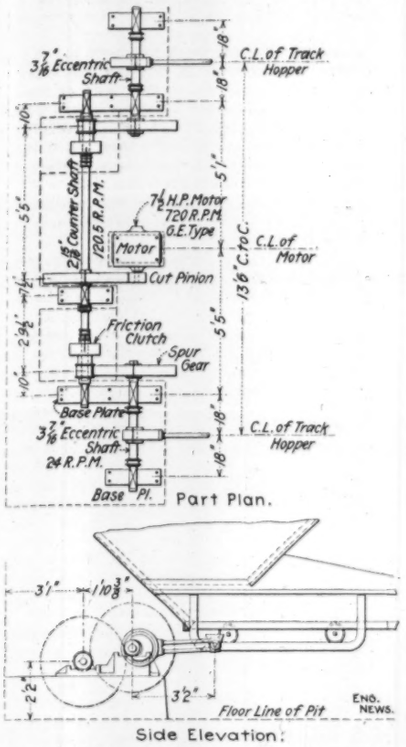


Fig. 3. Details of Mechanism of Reciprocating Feeders for Track Hoppers.

sists of ¼ in. steel trough, is fitted with a gate operated by a rack and pinion governed by a large hand wheel on the pinion shaft. This permits discharge into either of two belt conveyors running above the storage bins. Fig. 8 shows the discharge from the horizontal run of the elevator to the belt conveyor.

BELT CONVEYORS.

These conveying belts are 24 ins. wide, and run lengthwise over the coal bunkers. The trippers for distributing the coal in the bunkers move backward and forward, reversing automatically at each end of the run. The power for driving them is taken from the conveying belt, and they can be started or stopped whenever desired. The conveyors have a capacity of 125 tons per hour.

TOWERS.

The tower containing the crushers and elevating machinery is a steel structure 40 ft. 10 ins. wide by 29 ft. long. The vertical height from the top of the foundation to the elevator floor is 57 ft., and to the top of the roof 74 ft. The sides are of reinforced concrete construction composed of vertical studding of ¾-in. steel channels, on 14-in. centers, securely fastened to the structural steel of the tower; this framework is covered with expanded metal lath and plastered with a cement mortar to a thickness of 2 ins. The floors are of expanded metal and stone concrete. The roof is covered with book-tile sheathed with tar paper and covered with slate. Fig. 9 shows one tower and coke bin during the course of construction; the casing enclosing the vertical legs of the elevators is plainly shown in this cut.

COKE CONVEYORS IN RETORT HOUSE.

These conveyors receive the hot coke from the retorts and deliver it to the carriers encircling the coke bins. They are of the type shown in Fig. 10 and are composed of two strands of steel chain fitted with wearing shoes which support square steel bars at intervals of 25 ins., the bars forming the pushers. A section of the trough is shown in Fig. 11; it is constructed of steel angles and plates, the bottom and sides being lined with cast iron plates.

CARRIERS ENCIRCLING COKE BIN.

The carriers are of the pivoted-bucket type shown in Fig. 12. The buckets are made of malleable iron for stiffness and durability, and are fastened to two strands of steel-bushed strap chain of ample wearing surface and fitted with rollers. The discharge is effected by a movable dumping carriage traveling below the line of the carrier chain. The carriers have a capacity of 35 tons per hour at a speed of 40 ft. per minute, and each is gear driven by a 15-HP. alternating current motor. The construction of this type of carrier makes it especially suitable for handling hot coke or other abrasive material.

COKE BINS.

There are two storage bins to each retort house, each having a capacity of 33,000 cu. ft. The bin proper is a steel structure 19 ft. wide and 117 ft. long and has a vertical height of 49 ft. 6 ins. from top of piers to carrier floor. The floor and sides of the bin are of 6 in. stone concrete, the roofs of 4 in. cinder concrete and the side walls of the monitor of a 2 in. reinforced mortar construction, the same as that employed on the elevator towers. The bottom of each bin is provided with 18 screening chutes, 9 on each side, which screen the coke before it is delivered to the cars.

OPERATION.

The entire system is connected by a suitable arrangement of signals, so that any element of the conveying plant can be stopped or started at once.

The force employed in handling all the coal and operating the machinery consists of 1 general foreman, who has charge of the entire installation; 2 men at the track hoppers to dump cars; 2 men in the pit; 1 man for each scraper conveyor whose sole duty is to remove foreign material (such as picks, coupling pins, etc.) in the coal; 2 men in the tower, the man on the lower floor taking care of the conveyors and crushers and the one on the upper floor attending to the elevator machinery and belt conveyors; and 1 man for the machinery in each coke bin.

The entire installation, with the exception of the belt conveyors in the retort house, was designed and installed by the Link-Belt Company, of Philadelphia.

FIG. 4. VIEW OF TRACK HOPPER, SHOWING FEEDER MECHANISM.

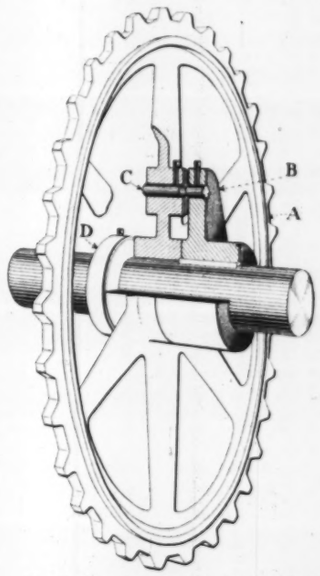


Fig. 5. Detail Showing Safety Device Applied to Conveyor Driving Mechanism.

AN OFFICIAL REPORT ON THE CONDITION OF THE EAST RIVER TUNNEL.

In our issue of June 27, we described the work in progress on the realinement of the Battery tunnel, under the East River, for the New York Rapid Transit Ry. Published criticisms of this work in the daily press led Mayor McClellan to order an investigation of the work to be made by the Chief Engineer of the Board of Estimate and Apportionment, Mr. Nelson P. Lewis, M. Am. Soc. C. E.

We print below, in full, the report of Mr. Lewis, presented to the Mayor on July 1:

Sir: On June 5 last you forwarded to me a letter addressed to you by John B. Creighton, secretary of the Brooklyn League, under date of June 3, referring to persistent rumors of faulty construction on the tunnel between Manhattan and Brooklyn, and instructed me to make an examination of the tunnel and report the results to you.

In accordance with your instructions I have devoted as much time as my other duties would permit to a study of the plans for this work, to the records of its progress from the beginning and to the work now going on, and have made such examinations of the tunnel tubes as present conditions permit. I have conferred not only with the engineers of the Rapid Transit Commission, but with those of the principal contractors and the sub-contractors who built the river section, and of the contractors who carried out the work of rectification of grades. All of them have courteously placed at my disposal the information in their possession and have given me every possible facility for inspecting the work.

WORK ACCOMPLISHED TO DATE.

Both cast-iron tubes have been completed for their entire distance. In the north tube the concrete lining and the ducts are practically complete from the Man-

hattan end to the lowest point, which is near the middle of the East River, where the tube leaves solid rock, while the bottom lining has been carried about to the point where the tube enters the reef of rock about 600 feet farther east. There is nothing but the cast-iron shell from this reef to the Furman street shaft, while from this shaft to the Brooklyn end of the tube the greater part of the concrete lining and some of the ducts are in place. The concrete track invert has been placed for the short distance between the Manhattan end and the Battery Park shaft.

In the south tube the concrete lining ducts and track invert are practically complete between the end of the tube and the cross tunnel at the lowest point, and the crossties are in position for the greater part of the distance. From here to the Furman street shaft there is nothing but the cast-iron tube, while from Furman street to the Brooklyn end of the tube the lining and ducts have been completed.

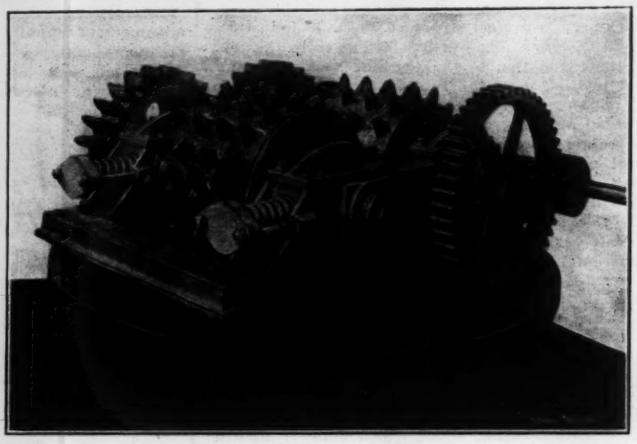


FIG. 6. VIEW OF CRUSHER.

The portions of the tubes which have been built in rock are in excellent condition, and the work is so far advanced that tracks could be laid and this part of the tunnel made ready for operation in a very short time. Where soft material was encountered great difficulties presented, and there were variations from grade and section which had to be corrected.

VARIATIONS FROM THEORETICAL GRADE.

North Tube—Beginning at the Brooklyn end the bottom of the tube is about 4 ins. below the theoretical grade, this variation decreasing toward the west to a point just east of Garden place, where the tube suddenly rose to 9 ins. above grade, then gradually approached true grade, crossed it about 100 ft. east of Hicks St., and 100 ft. west of Hicks St. dropped to 28 ins. below grade, this being the greatest departure. Up to this point the tunnel is wholly or in part above water level. The true grade was recovered in the next 100 ft., and from the bulkhead line the tube bottom was mostly above grade, the maximum distance being about 10½ ins., while at one point it fell 9 ins. below the grade. After crossing the bulkhead line the tube continued above the theoretical grade for over 500 ft., the maximum variation being 17 ins. It then ran very closely to the true grade for about 500 ft., and within the next 100 ft. it reached a maximum of 18 ins. below grade. For the remaining 200 ft. before the rock reef was reached the grade line was somewhat irregular.

South Tube—The grade of this tube from its easterly end shows slight variations from the true grade, with a maximum of about 5 ins. above and below, but after passing Hicks St. there is, as in the case of the north tube, a more noticeable departure, dropping to about 23 ins. below the true grade, which, however, was quickly recovered, and was closely followed to the bulkhead line, the maximum variations in this distance, which is about 900 ft., being 3 ins. above and somewhat less below the true grade. In both tubes the maximum departure from grade occurred just west of Hicks St., or at the point where the tubes became wholly submerged.

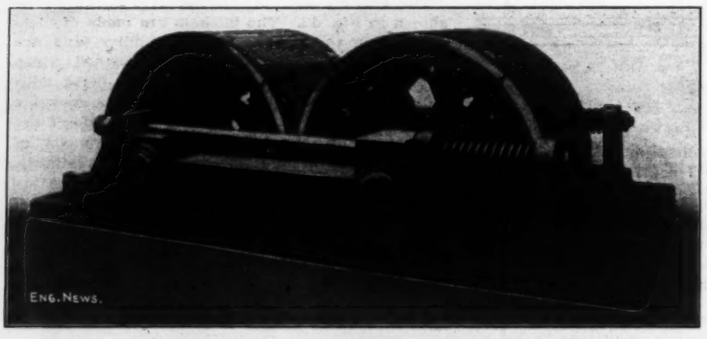


FIG. 7. DISINTEGRATOR.

Work was in progress on both tubes at this point at the same time—namely, in May, 1904—so that in both cases was presented simultaneously the problem of passing from material which was dry or partly in water to a position wholly below the water level. Work on the north tube was continued, with the results as to grade already outlined, but in the south tube operations were suspended until November, 1904, and it is a significant fact that in the south tube the variations from grade and the deformation are much less noticeable, the maximum east of the bulkhead line being 3 ins. and under the river section 6 ins.

As the material through which both tubes passed is precisely alike, the inference is that the contractors had gained a valuable experience in their work on the north tube, which was used to good advantage on the other.

SETTLEMENT OF THE TUBES AFTER BUILDING.

From the Brooklyn end to points about 500 ft. west of the bulkhead line, both tubes rest upon coarse sand of excellent supporting power. From this point to the rock reef and between the reef and the rock through which the west end of the tunnel is driven they rest upon a very fine sand and river silt.

The parts of the tubes resting upon this soft material have settled somewhat since they were put in position. Statements as to the time and causes of this settlement are conflicting. It has been claimed that this settlement may have occurred gradually during some months after the tunnel was driven. The engineers of the Rapid Transit Commission and of the Rapid Transit Subway Construction Co. assure me that the settlement, which reached a maximum of 12 ins. in the north tube and 9 ins. in the south tube, occurred when air pressure was reduced before the joints had been caulked and the fine material coming into the tubes left spaces into which they settled. That this was what actually occurred appears probable from the fact that the contractors made an attempt to adjust the grades by opening the bottom of the tubes at high points in order that material might flow into them, thus causing them to settle to a uniform grade line, and I am informed that in this they were partially successful. So far as I can learn there has been no perceptible settlement during the past year.

SUPPORTING PILES NOW BEING PUT IN.

In order that further settlement may not occur either through inherent lack of supporting power of the soft material above referred to, or through any change in the character of the material which may possibly be caused by the vibrations due to train movement, supporting piles are now being placed under those portions of both tubes which rest in this material. In the space west of the rock reef these piles are being driven about every 35 ft. East of the reef and until the tubes reach coarse sand, the piles are placed about 50 ft. apart. These piles are in pairs, 7 ft. apart between centers, each pile consisting of a steel tube 20 ins. in diameter, filled with concrete and reinforced with steel rods and hoops. Each pair of piles supports a cradle made of concrete, strongly reinforced with steel, this cradle being 11 ft. long and 5½ ft. wide, equivalent to three rings of the tunnel tube.

Under the north tube all of the supporting piles have been put in place east of the reef, and all but seven pairs west of the reef. Under the south reef five pairs remain to be driven to the east and eight pairs to the west of the reef. There will be 63 pairs of these supporting piles, all of which will go to rock or hard pan, their length varying from 4 ft. to about 75 ft. This work is being done very rapidly, and will be completed in about three weeks.

DEFORMATION OF THE TUBES.

Flattening occurred in both tubes and was most noticeable where there were sharp changes in the grade lines. If a ring of the tunnel were to be tightly bolted together and placed in a vertical position, there would undoubtedly be a certain amount of flattening, which would be increased by any loosening of the bolts. This flattening or deformation is most noticeable in the land section, reaching its maximum as in the grade variation, about where the tubes became entirely submerged, where it was about 10 ins. in the north and about 7 ins. in the south tube. Between this point and the bulkhead, the south tube, which followed the grade more closely, showed a maximum flattening of less than 4 ins., and still less under the river.

CORRECTION OF GRADE AND SECTION.

Where the departure from grade and section has been sufficient to interfere with passage of trains or to endanger the integrity of the tubes, the plates have been removed and concrete, and in one case brick masonry, has been substituted, in some places for the roof and in other places for the bottom above the water line, while under water new plates giving an elliptical section with the longer diameter vertical, have been put in place

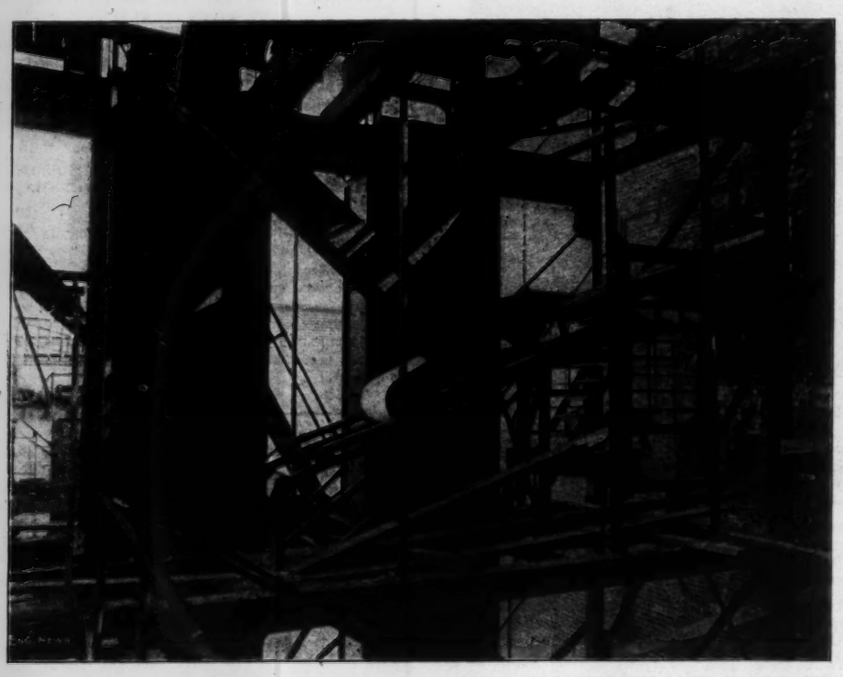


FIG. 8. VIEW SHOWING DISCHARGE FROM ELEVATOR TO BELT CONVEYOR.

of the old ones. This was a very difficult undertaking, but it has been successfully done by the use of novel and very ingenious methods.

CRACKED AND BROKEN PLATES IN THE TUBES.

Much has been said about cracked and broken plates.

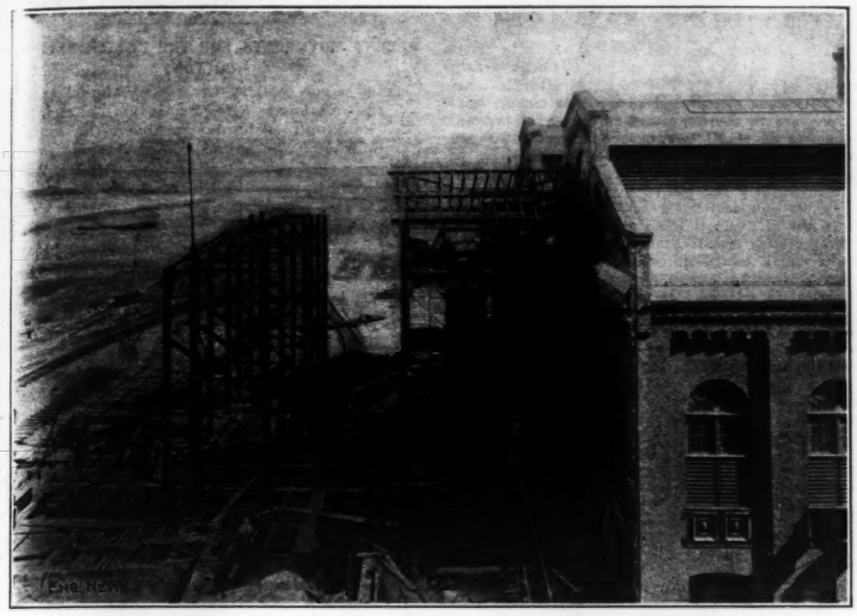


FIG. 9. ELEVATOR AND CRUSHER TOWER UNDER CONSTRUCTION.

By far the greatest number occurred on the Brooklyn land section, of both tubes, where the material was coarse sand and gravel and where the tubes were wholly or in part above water, and, as in the case of the flattening, they are most noticeable where there are sharp changes from the true grade line. This would appear to indicate that the cracking of plates was not due to the inability of the tubes to retain their shape or to perform

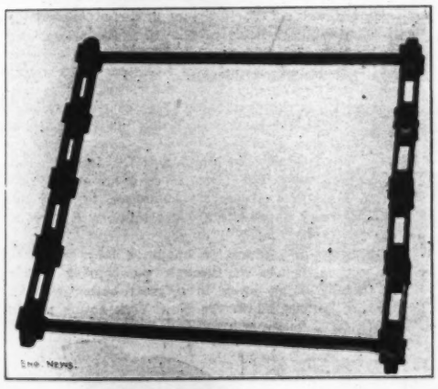


Fig. 10. Coke Conveyor Chain.

their proper functions after they were in position, but to the stresses to which they were subjected by the irregular course of the shield when it departed from the proper grade and the efforts to bring it back after such departure. There are few cracked plates in the river section, especially in the south tube, and I am informed

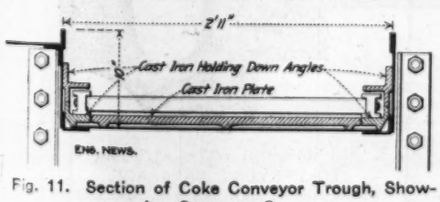


Fig. 11. Section of Coke Conveyor Trough, Showing Conveyor Car.

that nearly, if not quite all, of the cracking occurred immediately behind the shield during the progress of the work. None of the cracked plates appear to be leaking in that part of the tubes east of the Furman St. shaft, although for about 600 ft. the tubes are entirely below mean high tide. In the portions which are still under air pressure I could see no leaks, either at the joints or from cracked plates, but some may develop when the air pressure is again removed. They can, however, be stopped as have been those east of Furman St.

The inability of the tubes to retain their shape and carry moving trains without leaks, settling and deformation depends upon the character of the material in which they lie. This material, except for about 800 ft. east and about 600 ft. west of the rock reef, has ample supporting power. As to the very fine sand and river silt on both sides of the reef there is a difference of opinion.

I have examined a number of samples, most of which were taken from under the tubes when plates were removed for the purpose of sinking the supporting piles. Some of these samples are in water, while others are dry. The former appear to be nearly all very fine sand, while the latter have the appearance of a putty-like mud, although all contain a large amount of exceedingly fine sand.

While some of the engineers who have this work in charge seem confident that the fine material on each side of the reef is capable of supporting the completed tubes with the moving trains, it is realized that the problem is a novel and difficult one, that tunnels are now being built beneath both the Hudson and the East Rivers under conditions which have not been found elsewhere; that the tubes, if not otherwise supported, will settle if the underlying material flows into them; that in one of the Hudson River tunnels the original plans called for supporting piles, and that it is, therefore, prudent to insure against settlement by the supports now being put in place. That the most unfavorable material encountered has considerable supporting power there can be no doubt. Should this prove to be even less than was believed when it was decided to introduce the supporting piles, the number of these supports can be increased at any time.

I have endeavored to describe the conditions as I have found them and to reconcile conflicting statements and opinions where possible.

The public is impatient of delay in the completion of this great work, but in view of the difficulty of the undertaking and the unusual conditions encountered, such delay as has occurred is not surprising. I have not seen enough of the progress of the work to estimate the time still required for its completion, but I am convinced that the obstacles are being over come, and that the experimental operation of trains, which will precede the opening of the tunnel to public travel, will demonstrate its entire safety.

Respectfully,

Nelson P. Lewis, Chief Engineer.

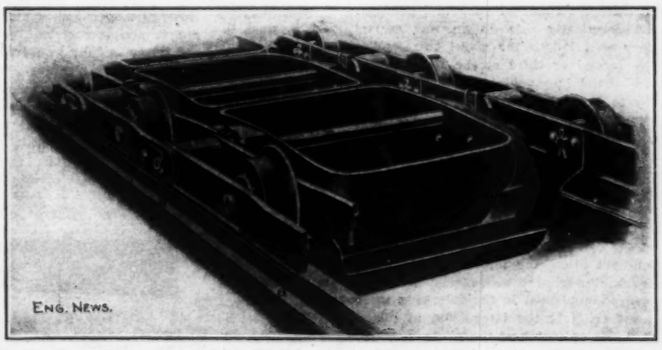


FIG. 12. A PORTION OF THE CARRIER CHAIN ENCIRCLING COKE EIN.

SOME RECENT IMPROVEMENTS ON COMPRESSIVE RIVETERS AND PNEUMATIC HAMMERS.*

By CHESTER B. ALBREE,† M. Am. Soc. M. E.

In compressive riveter work there are two or three types which are quite familiar, the oldest type being the straight hydraulic machine invented by Tweddel in England, and later on, the pneumatic riveter by Allen of New York, who was perhaps the first to make it a success. Later came the hydro-pneumatic riveters. With the hydro-pneumatic riveter we have been making some experiments, and it was found to be advisable for several reasons, notably for greater economy of air, simplicity of construction and better action, to try to improve the methods that had been in use. The pressure required in driving rivets differs from that required in punching materials in that the greatest pressure comes at the first of the stroke, when the punch comes down on the material; In riveting, however, especially hot riveting, the easiest work is when the die first strikes the rivet and the greatest pressure is required to finally form the head. That being the case it can readily be perceived that a constantly increasing pressure would be the theoretically correct pressure to drive rivets. This pressure is most easily obtained by means of the toggle joint, which theoretically gives an infinite pressure with an infinitesimal movement at the end of the stroke. In practice, of course, an infinite pressure is not reached, but, as most riveters are of horse shoe or yoke type, the limit pressure is the yielding point or the bending point in the yoke. In straight toggle joint machines the general idea is shown in Fig. 1.

In practice it is found that when the cylinder has made seven-eighths of its stroke the pressure line of the rivet dies rises up to about 15 times the pressure in the cylinder. By that time the pressure has increased to within about 1-16-in. of the final stroke of the machine, and beyond that point the probabilities are that there would be spring in the yoke. If the yoke is made strong enough not to spring at all, it would be so heavy as to be utterly unmanageable. So it is only necessary that deflection should not occur at a pressure below that necessary to drive the rivet. Hence the toggle joint arrangement is the best possible arrangement for driving rivets.

But there are certain drawbacks in the practical application of the toggle pressure. The principal one is that its stroke is absolutely fixed. It never varies for a given leverage. In riveting there is liable to be 1-in. or 2 ins. or maybe only ½-in. thickness of plate, and in order to have the maximum pressure just as the die comes to the surface of the plate it is necessary to adjust the distance between the die and the point of maximum pressure by means of a screw actuated by hand. In work that does not vary it makes little difference, but in ordinary structural work, and boiler work, rivets have constantly to be driven through different thicknesses of material, and each time it is necessary for the operator to adjust the screw. That requires a certain amount of skill, and if it is not done correctly the chances are that the rivet will not be driven sufficiently tight, if maximum pressure is not reached at the close.

To overcome this difficulty of adjustment the hydro-pneumatic machine was devised, which is nothing more nor less than a hydraulic intensifier. The ram alone gives a very small but powerful motion, and it is necessary in riveting to have clearances, in order to go over angles, stiffeners, etc., so it is desirable to have a longer stroke. Of course high pressure is not needed over a longer distance than, say 1¾ ins. The question then was how to get a clearance movement. This was accomplished by putting a little extra cylinder below the air cylinder. The air pressure, acting on its piston, forces liquid into the ram cylinder at low pressure, and by this means gives 3 or 4 ins. of preliminary adjustment.

*Paper read before Engineers' Society of Western Pennsylvania, Feb. 5, 1907.

†President, Chester B. Albree Iron Works, Pittsburg, Pa.

The objections to this form are: first, it is very difficult to pack, and second, in order to get two inches of die motion with a maximum pressure of 50 tons, it requires a 15 to 20-in. stroke in the air cylinder, and a very high pressure, sufficient for the final closing pressure throughout this stroke in the ram cylinder and plunger cylinder, thus wasting power. The practical advantage is that it does not require skilled workmen to adjust the dies; they

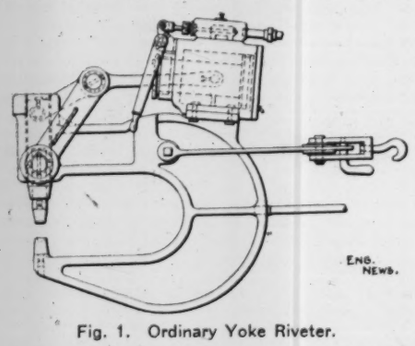


Fig. 1. Ordinary Yoke Riveter.

adjust themselves. It occurred to us that we might get the desired toggle joint effect and yet have an automatic adjustment, and this paper concerns the device for the accomplishment of this.

In Fig. 2 is shown the first attempt on the left, and also the perfected form on the right. As far as the toggle joint action goes it is practically the same as the first machine described. The pressure from the toggle, in the first form machine, is transmitted from the large area of the plunger to the top of the ram and also through a pipe to the adjusting cylinder. The ram being smaller in area and free to move, advances more rapidly than the plunger and continues until the rivet die on its extension strikes the projecting rivet. As the plunger continues, the pressure in the cylinder is limited by the pressure due to the spring in the adjusting cylinder, which is only 20 lbs. per sq. in., insufficient to upset the rivet beneath the ram. Hence the liquid will now displace the piston in the adjusting cylinder, the ram remaining stationary. As soon, however, as the projection on the plunger enters the ram cylinder the full toggle pressure is transmitted through the incompressible liquid to the ram; forcing down the rivet; and the differential area above forces the remaining liquid in large plunger bore, into the adjusting cylinder.

During the downward motion of the ram the liquid beneath it is forced into the opposite end of the adjusting cylinder; against the spring pressure. It is obvious that the ram may move its whole adjusting stroke, or none at all, up to the time that the projection on the plunger enters the smaller area; after which the further travel of the ram is that of the plunger, until the ram meets opposition greater than the pressure of the toggle; when it will stop. This arrangement, therefore, automatically adjusts the point of maximum pressure to suit the work. On the return stroke the direct pressure acts beneath the ram, as well as the suction of the plunger, to raise the ram to its original position.

Theoretically this design was correct, and it worked very well indeed for about two strokes. At the end of the second or third stroke the packing was gone and it was found impossible to hold the pressures. The trouble lay in the fact that cup leathers were put at the end of the plunger, and when the cup leathers entered the chamber, the moment the pressure rose to a high point it tended to cut the leather right out. So in order to make the device practically as well as theoretically successful, it was necessary to devise some scheme to have the leather cups, which hold better than any other hydraulic packing, move always surrounded by the walls of the cylinders, and pass no ports whatever. To do this and yet allow the liquid to pass freely from the upper to the lower part was rather a difficult proposition. It was accomplished in the following manner:

Referring to the later form in Fig. 2 it will be noted that the extension of the plunger, when fully up, projects into the smaller area of the ram cylinder; and that cup leathers are used to pack it. In the interior of this extension is a valve of the poppet type, but having a stem carrying on its end a small piston. This valve is normally held open by a spring. So long as the pressure above and below this small piston is the same, the spring holds the valve open; but when the pressure below is greater than above the piston will move up, closing the poppet valve. This occurs only when the port M leading into the space below the small piston is closed; due to its passing from the large diameter bore to the smaller ram bore. When closed, the toggle pressure acts on the liquid below the plunger extension, raising the pressure sufficiently to move the small piston and connected valve; and later exerting very high pressure on the poppet valve; shutting it perfectly tight. The adjusting action is precisely the same as in the first type, except that the liquid flows through the plunger extension instead of around it, during the adjustment part of the stroke. With this arrangement it will be noticed that all of the plunger and ram packings are continually enclosed by cylinder walls and pass no ports or openings, so that the packing leathers are not injured. The adjusting device is patented and the poppet valve device is now being patented.

In any device of this kind there is always a certain loss of liquid due to a film in the ram (although theoretically the quantity of liquid is constant) and in the course of a little while there would be a partial vacuum inside and pressure on a cavity would not give good hydraulic pressure on the rivet. It was therefore necessary to provide a constant source of supply of the liquid, so arranged that when the pressure rose in the confined liquid it would not blow out, but when there was a vacuum in the system additional liquid would run in.

This loss of liquid is made up from a small storage, or compensating cylinder, full of liquid; having a piston with a spring behind it, connected to the larger bore of the plunger by a pipe, having a check valve in it. Whenever there is pressure in the plunger cylinder the check valve remains closed; but when the toggle is fully back, and the piston in the adjusting cylinder is against its cylinder head, so that no pressure due to its spring is exerted on the liquid, any loss of liquid will tend to create a vacuum in the plunger cylinder, and then the check valve will open and oil flow out of the compensating cylinder, under the pressure of the spring acting in its piston, to replace that lost.

PNEUMATIC HAMMERS.

In pneumatic hammers of nearly all makes, one of the sources of trouble has been that if the workman picked up the hammer and put his finger on the trigger when

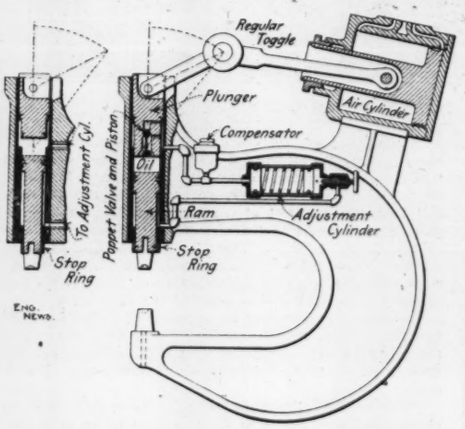
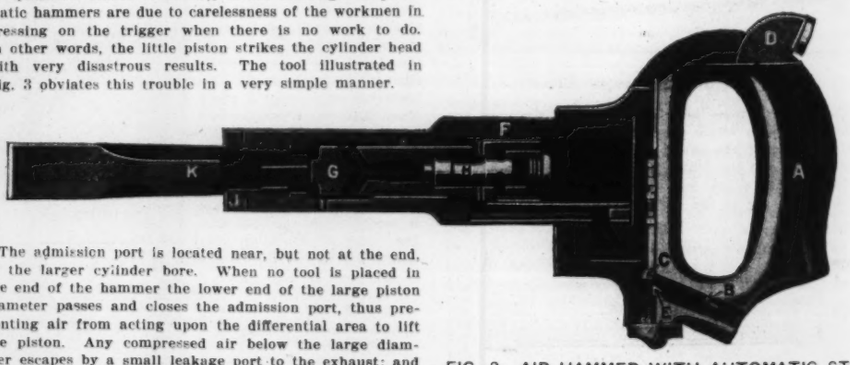


Fig. 2. Yoke Riveter With Automatic Regulation for Adjustment to Different Opening Widths.
(Made by Chester B. Albree Iron Works Co., Allegheny, Pa.)

there was no chisel or rivet-set in it, the piston would begin to reciprocate, and not having any tool to strike at the lower end, it would strike the cylinder head; and in a matter of a minute or two it would smash the piston or cylinder. About 75 or 80% of the breakages of pneumatic hammers are due to carelessness of the workmen in pressing on the trigger when there is no work to do. In other words, the little piston strikes the cylinder head with very disastrous results. The tool illustrated in Fig. 3 obviates this trouble in a very simple manner.



The admission port is located near, but not at the end, of the larger cylinder bore. When no tool is placed in the end of the hammer the lower end of the large piston diameter passes and closes the admission port, thus preventing air from acting upon the differential area to lift the piston. Any compressed air below the large diameter escapes by a small leakage port to the exhaust; and this leakage port is only open when the admission port is closed. In hammers actuated by valves exterior to the piston, it seems impossible to use this device, and attempts have been made to mechanically close such valves, but they do not appear to be very successful. The same effect is obtained, but at the expense of loss of air, when the leakage port is designed to open when the piston is at the extreme end of the stroke, but does not close the admission port. Patents are now pending for these improvements.

A hammer of this design, with 100 lbs. pressure in the pipe, can be picked up, the throttle opened, and if the tool is fully in place it will not start; whereas in most other air hammers, the moment the trigger is touched the tool starts and in a few minutes the whole mechanism is racked until it is good for nothing.

FIG. 3. AIR HAMMER WITH AUTOMATIC STOP TO PREVENT BREAKAGE.
Will not operate until tool is in final position.

RECENT MOVEMENTS FOR THE BETTER BALING OF COTTON.

In a paper read at the recent annual meeting of the National Fire Protection Association, Mr. Benjamin Richards continued the agitation for improving the baling of American cotton and reducing the present loss of over a million dollars each year by fires set by cotton bales. Progress toward this end is shown in the following excerpts from this paper:

Up to a year or so ago the cotton farmer had little interest in his crop, as it was usually owned by his creditors even before it was raised. The farmer was in debt for clothing, food, rent and often for the cottonseed itself to the full value of his future crop, which at the end of the year he would sell to cancel his indebtedness and then proceed to go in debt again in anticipation of the next year's crop. It was but natural that the grower took little interest in the care of his cotton or the manner in which it was marketed.

Recently, however, the price has been so favorable that the grower to his great surprise has found that he could go back home not only with his debts paid, but a little extra money in his pocket, which he could call his own. As a result, the farmer has begun to appreciate the real value of his crop and desires to make it worth as much as possible.

The South, with old-time energy, seems to be rising to the occasion and by forming Growers' and Handlers' Associations, those interested are gradually getting matters into their own hands, and are asking about what they can do to improve the conditions. They claim that the price of cotton should be kept up in order that they may make a fair profit and be able to withdraw the women from the fields and send their children to school. The manufacturers have not been slow to point out the present bale troubles which they claim should be improved if a high price is to be maintained.

At the first conference of Growers and Manufacturers held at Washington a year ago, a committee was appointed, of which Mr. Charles H. Fish, of Dover, was chairman, to report on the needed improvements. Their recommendations covered the main faults affecting the spinners but did not go into the matter of fire prevention. They suggest bales of standard dimensions, new burlap or cotton canvas covering, ten ties with Egyptian style of buckle, and that all cotton be sold by net weight. A committee was appointed to further consider the matter and report at the conference to be held next October. It is fair to say for the growers that many of them do not know what a good bale of cotton looks like; and it has been recommended to Mr. James R. MacColl, president of the coming conference, that he obtain some Egyptian and Indian bales for exhibition in order that the growers may appreciate the great inferiority of their bales.

The growers also expect to handle a large proportion of the cotton themselves through warehousing associations, thereby doing away to a great extent with the speculating carried on in the New York cotton market.

Thus by keeping in touch with the consumers, they will be enabled to keep informed regarding their complaints and a general improvement of conditions should be expected.

*"The Cotton Bale as a Source of Loss by Fire," presented before the National Fire Protection. New York City, May 22 to 24.

THE LIDGERWOOD ELECTRIC FRICTION-DRUM WINCHES FOR CAR FERRIES.

For hauling the heavy floats of car ferries up to the bridge apron, geared hand-winches have been used, much like those for bringing passenger ferry boats up to the ferry bridge and mooring them fast. The great size and weight of car floats makes such an operation laborious, difficult and oftentimes uncertain.

It requires a man at each of the two winches and often a third man to direct their work. Even with the double-geared winches in use the power required is often so great that the men can make but little headway. When high winds swing the floats out of line the men at the winches are unable to bring the floats up to the aprons squarely so as to bring the rails on the floats and on the aprons into line and to allow the toggles to be thrust home and the extra steel mooring lines made fast. Even after the mooring has been accomplished and all is snug, the hand winches leave one very important contingency unprovided for. This is the possibility of the mooring ropes being parted or the mooring apparatus torn away by the tremendous thrust of a train of cars, run upon the float and brought suddenly to a standstill by the brakes, or, as often happens, striking the buffer at the end of the tracks. In such cases the whole impetus and weight of the moving train and locomotive is transferred to the moorings, connecting the float with the bridge apron. Under these circumstances, the steel mooring ropes are often parted or the nut and screw apparatus by which they are attached to the bridge apron is broken or torn from its fastenings.

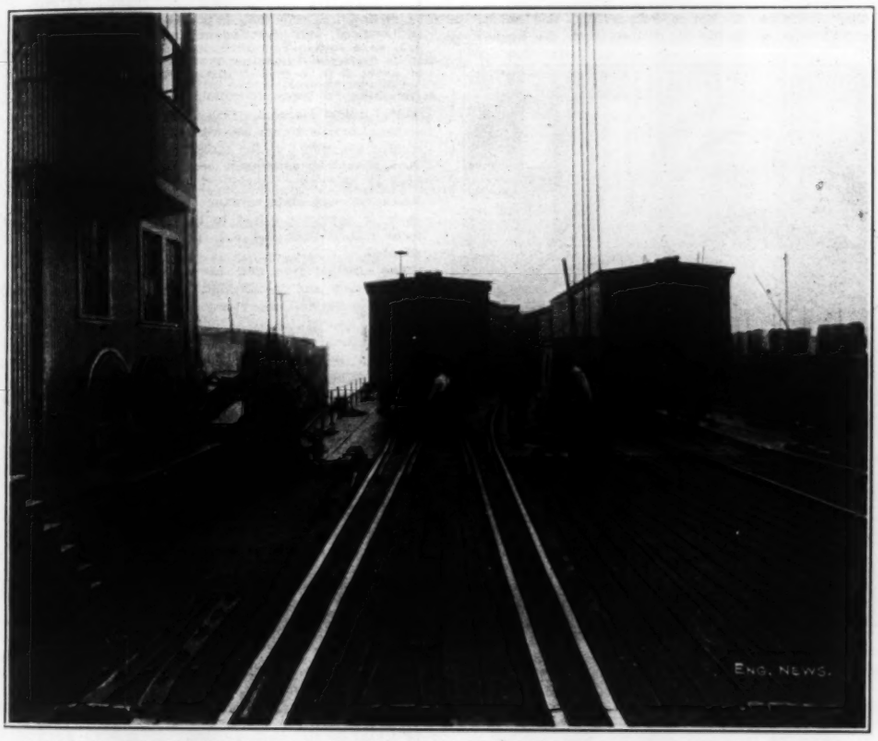


FIG. 1. INSTALLATION OF A LIDGERWOOD MOTOR DRIVEN WINCH AT THE GREENVILLE, N. J., TERMINAL OF THE PENNSYLVANIA R. R.

With the ordinary winches no provision is made to safely meet such contingencies. The winches are merely locked with a ratchet and pawl, and if a tug or a tow drifts against the side of the float at its out board end, or a train is brought to a sudden stop on the float, or if any other accident happens to tear the float away from its moorings, then the whole strain comes on the hauling-in hawsers and the winches. These give way and there is then nothing to prevent a gap being opened between float and apron into which car trucks or even whole cars may be precipitated. Such accidents have not been very uncommon.

With the new Lidgerwood slipping-drum hauling-in winches all these troubles are met fully. Hand power is replaced by electric motors, and the whole operation of hauling in is placed under the direct control of one man. The operator stands in a tower alongside of the apron where he has unobstructed view of the incoming float in one direction and of the approaching cars in the other. In the tower room are the controllers for the winches and the apron lifting motors. This tower is shown in Fig. 1, a few feet above the winch.

As a float approaches, the operator adjusts the height of the aprons so that the decks, rails and toggles will aline. As soon as the deck-hands have made fast the hauling-in hawsers he puts the electric winches in operation. Each of the two winches has its own motor and controller, so that stress can be brought on one or both the hauling-in hawsers, according to the operator's judgment of the best way of bringing up the float or swinging it into position. The stress upon the hawsers can rise to a fixed limit, but never beyond this. The slipping-drum frictions are set so that the winches can put a desired stress on the hawsers, but the moment this is exceeded the drum slips. The moment the drum slips the stress is slightly reduced and holds this valve as long as the slipping continues.

The operator winds in the hawsers until the float is brought into the desired position, and keeps the winches in operation while the deck hands are slipping into place the toggles which maintain the rail alinement, and while they make fast and screw up the steel mooring lines. When the float is snug against the apron, of course the hawsers can be wound no more, and the winch simply slips, keeping the allowable tension on the hawsers. Should the float show any disposition to rebound or swing out of place in being brought up to place, the slipping drums prevent this from endangering the drawing-in hawsers and at the same time maintain a constant tension upon them, sufficient to promptly check the outward motion of the float and bring it back to place.

While the cars are being taken off and the float is being reloaded the operator remains where he can view the float constantly. Should any accident, as mentioned, part the mooring lines, the hauling-in winches can check any outward movement of the float and draw it back to place. The slipping drum gives for an instant, preventing any breaking stress coming on the hawsers. The operator should notice such an action immediately, and by putting the winch motors into operation can warp the float back to the bridge apron before a dangerous gap is opened.

The operation of hauling in is, therefore, conducted under the best conditions for promptly bringing the float into place and holding it there without a possibility of breaking either of the hauling-in hawsers.

The Lidgerwood electric slipping-drum hauling-in winches were designed to meet the ideas of the Pennsylvania Railroad, when preparing to put in use the great yards and ferries established at Greenville, N. J., and South Brooklyn, N. Y., for transferring freight from the main terminal at Jersey City to Long Island and the several railroad terminals in the harbor. The three large car slips at Greenville are now equipped with these Lidgerwood winches, which have been in continual and successful use there, since the ferry was opened in October, 1904. During this time they have been subjected to the most severe tests. They seem to have fully met the expectations of their builders and the railroad officials.

Each of these powerful hauling-in winches, complete with its motor, occupies a floor space of 56½ ins. in length by 44 ins. in width and is 52½ ins. in height. Each winch is actuated by a direct-current 500 volt, series, hoisting type, motor, rated nominally at 10 HP., but so geared as to operate at 900 r. p. m. and to develop only 5 HP. This power is ample for the operation of a winch even when hauling in the largest and most heavily loaded floats.

The motor is connected with the drum by a heavy steel worm gear. This gear runs in a bath of oil, and each end of the worm shaft is provided with a roller thrust bearing.

The drum is 14 ins. in diameter with a 14-in. face. It carries a 6-in. manila hawser and hauls in at a speed of 10 ft. per min.

The slipping-drum friction clutch is of the type developed by Mr. Spencer Miller for maintaining a constant tension on the cables used in the Lidgerwood cableways for coaling warships at sea. It is designed to slip continuously under full hawser tension for an hour at a time, if desired, without destructive wear or excessive heating and at the same time to maintain an even tension on the hawser of any desired amount, according to adjustments.

The drum is normally loose upon its shaft and it is lined with bronze bushings to take the wear when it is slipping. At its ends the drum is provided with friction rings made of steel. Opposed to these are friction blocks composed of soft steel and soft cast iron. The surfaces of the rings and blocks are brought together with the required degree of pressure by means of a finely threaded screw and a combination of springs, to prevent setting and welding of the rubbing surfaces. The main features just mentioned can easily be distinguished in Fig. 2.

The frictions can be set to give any desired tension before slipping. Those used at the Pennsylvania Railroad Ferry are set so that each exerts a strain on its hawser of 11,000 lbs. before it begins to slip. This strain is reduced to 9,000 lbs. as soon as the drum slips, and this pull is exerted continuously as long as the drum is slipping. The friction surfaces, as noted before, are of special iron and steel compositions found advantageous by Mr. Spencer Miller in his researches, and the friction drive has some noteworthy characteristics. The coefficient of friction for the surfaces used is high and unusually near the same value for rest and slipping. The figures quoted above would indicate about 18% difference in the apparent coefficients of friction for rest and at the moment of slipping. Such a value is much less than with other friction devices, such as brake shoes on car wheels, for in-

stance. The slipping may be continued for long periods without materially lessening the coefficient or producing an undue amount of heat, which cannot be properly radiated.

This type of a friction drum may be regarded as quite a distinct advance in the manufacture of such devices. It was first developed for the Lidgerwood Sea Coaling Cableway and has become an important feature in logging engines and hydraulic dredges, besides the application noted in this article.

The patents on the friction drive are controlled by the Lidgerwood Manufacturing Co., 96 Liberty St., New York City. To the officers of the company we are indebted for the information herein presented.

THE DEVELOPMENT OF GASHOLDER CONSTRUCTION.*

By GEO. H. CRESSLER,† Jun. M. Am. Soc. M. E.

The development of gasholder construction divides itself naturally into three periods of which the lines of demarkation are surprisingly distinct. The first, characterized by uncertainty and experiment, ended with the general adoption of the cylindrical form of holder in 1813. The second, in which the distinguishing trait is the universal use of cast iron, closed in 1882 with the invention of the light steel guide frame. The third period, that of to-day, is signalized by the high degree of exact engineering knowledge that has been attained. When William Murdock was carrying on those experiments that were the beginning of our industry he found the gasholder already at hand. Without this device the application of gas to commercial purposes would have been almost impossible. Gasholders, as employed by Murdock and his contemporaries, were rectangular in form, made of heavy plates, strongly braced from within. They were suspended in cast iron tanks by chains passed over beams and heavily counterweighted. Five hundred cu. ft. capacity was considered rather large. The deep tanks were considered a source of great difficulty and expense, and the early engineers were soon devising methods of making shallower ones answer. Samuel Clegg was particularly active, inventing two styles of holders to meet the difficulty, neither of which was as successful as ingenious. The first, a rotary holder consisting of an annular vessel which revolved horizontally in a shallow tank, undoubtedly suggested the idea of the station meter. It was succeeded by a collapsible holder, the ingenuity of which was certainly commendable. It was made of light plates, in form like the gabled roof of a house, and opened and closed like the leaves of a portfolio, as the gas entered or was drawn off. This unfortunately was no more popular than the one of rotary form, and the few installed were replaced by the cylindrical holders which now began to come into general use. The question of tanks was still a serious one. Wooden ones were tried, and second-hand vats from the brewers sometimes used. These were quite unsatisfactory, however, as the hoops were liable to come off and the tanks to suddenly burst, causing, as a contemporary remarks, "considerable annoyance."

FIG. 2. ARRANGEMENT OF FRICTION DRIVE, HAWSER, DRUM AND MOTOR, LIDGERWOOD ELECTRIC HAULING-IN WINCH.

By 1815 illuminating gas was coming to be recognized as a success. Holders became larger and larger until they reached the unprecedented size of 6,000 cu. ft. capacity, though in the face of such opposition from those who considered them to be dangerous magazines filled with a high explosive and apt at any time to blow up, scattering death and destruction. The great London gas companies were formed and financed. With sufficient means at hand holders were built of continually increasing capacity, and the second period of the development of their construction was well under way. This was marked, first, by a lightening of the containing bells by the removal of a great part of the heavy interior bracing, although the crowns were still heavily trussed and remained so through practically the entire period. The trussing became so massive that one dissenting engineer questioned whether the framework was put in to support the plates or the plates to support the frame. The opinion was freely expressed that the day of untrussed crowns would come, but no one was then so unconservative as to take the responsibility of building one.

As the demand for greater capacity increased the telescopic principle was evolved and introduced as early as 1840. Two-lift holders were built and were very generally adopted. The 3-lift was looked upon with distrust. As late as 1879 not more than four or five were in existence, and these "King's Treatise" speaks of as being interesting as an engineering achievement, perhaps, but objectionable from their lack of simplicity.

The use of masonry tanks was general, though cast iron was much employed, notwithstanding its great expense. Tanks of very considerable magnitude were erected of this material, being built of comparatively small plates, generally ornamented with paneling and beading, bolted together in tiers. Each tier was hooped with a ring of flat bar iron to add to its stability. Steel plate was not greatly favored, and was but little used until a comparatively recent date, except in tanks of annular form, where two concentric rings of steel were employed, the narrow trench between them forming the water box.

The primitive method of supporting the holder in its tank was of course impractical with the holders of large diameters. John Malam, one of the most eminent of the early engineers, devised the system of sustaining the holder by means of a center mast and counterweights.

This arrangement had a very considerable degree of success, particularly for shells of small diameter. A few holders constructed on this principle are still in use. One of about 30,000 cu. ft. capacity was built in Fort Wayne, Ind., in the early 50's, and was demolished only last year. The logical method, however, is the use of guide framing, which seems to have been employed first about 1830. Originally, and for many years, standards, girders and guide rails were made wholly of cast iron. The standards at first took the form of tripods, which soon gave place to massive columns. These were, from their great weight, practically self-sustaining, the girders being merely tacked on. In accordance with Victorian taste, heavy ornamentation was the rule. Girders were decorated with wreaths and festoons. The columns became fluted pillars with Doric capitals, in what has been characterized as an absurd attempt to imitate, in iron, architectural forms originally designed for and applicable only to stone. Occasionally the moulding of the deeply paneled base would be so under-cut, for the purpose of "showing bold," that there would be but little metal left, making the columns weak at the very point where they should have been strongest. In 1869 a column at Limerick thus adorned snapped off in a storm, leveling its own holder and carrying down in the general wreck another holder that was nearby.

Gradually, with the increasing knowledge of stresses, and with the cheapening of iron, there came a change. The cast iron girders, first to go, were replaced by girders of angles with a cast web of open filigree pattern. The latter soon gave way to a network of heavy lattice bars. During the '70's columns appeared of similar construction. Though they were still of enormous weight, they were received with distrust by the more conservative engineers, and the suggestion that they might be somewhat lightened met with great opposition. Their unsightliness, the danger of their rusting and readily deteriorating, their apparent frailness and lack of stability were disclaimed against.

In 1882, Mr. George Livesey, at that time Engineer of the London South Metropolitan Gas Company, read a paper before the English Institute that gave such an entirely new aspect to the whole subject of guide framing that its presentation may have been said to have marked a new epoch in gasholder design. Considering, first, the system of cast iron columns, Mr. Livesey showed that their power to resist a force applied at their tops depended entirely on the strength of the metal at the base of each, the strength of the entire system, of course, being equal to the strength of each column multiplied by their total number.

The entire theory is summed up in the following sentence which is here quoted verbatim from Mr. Livesey's paper:

> The diagonal bracing has the effect of converting the series of isolated uprights into a cylinder whose base is equal to the diameter of the tank, usually with a height less than the diameter; and providing the various members composing this cylinder—the uprights, the girders or struts, and the diagonals—are properly proportioned and secured, and of sufficient strength, it must stand as firm as a rock. You have, in fact, one column, say 100 ft. in diameter, in the place of 16 separate columns, each of about 3 ft. 6 ins. in diameter.

It must be borne in mind, however, that the use of lateral rollers places a strain upon the columns which the diagonal braces do not absorb. As the columns, therefore, receive the whole of the stress from the gasholder, their form should be such as is best suited to resist the pressure of the guide rollers. The upright girder standard (lattice or web-plate column), being strong from front to back, is perfectly suited to this service, and hence this form rather than the old cast iron column should be adopted.

The abstract from Mr. Livesey's paper is of necessity fragmentary and insufficient. The careful study of the original will well repay any one interested in this subject. It constitutes an actual contribution to knowledge, and the development of the principles set forth in it has not only made possible the 12,250,000 cu. ft. capacity holder at East Greenwich, but also has assured to the manager of the smallest plant a holder designed on absolute and correct engineering principles. Its postulates have been furthered and developed by a distinguished body of engineers in America and Europe, making possible the flying lift and the unprecedented achievements in spiral and cable guiding. In practical construction the "hit-or-miss" methods have entirely disappeared.

The gas managers of to-day have the certain assurance that every particle of material entering into the construction of a modern holder has its place because of an unchanging principle of engineering, and that every plate, structural and rivet, plays its assigned part in making for strength, durability and efficiency.

*From a paper read at the Milwaukee meeting of the Wisconsin Gas Association.

†501 West Berry St., Fort Wayne, Ind.

DIVIDENDS OF UTAH MINES are summed up in an editorial of the "Mining Reporter" of Denver, Colorado. Since 1880, when Utah became a prominent mining district, the mines of the state have paid nearly $75,000,000 in dividends. The recent annual production of mineral is valued at about $30,000,000, yielding a profit of something like $5,000,000. For the first six months of the current year 16 prominent companies have distributed about $2,000,000 in dividends.

It is locally estimated that the total mine dividends for 1907 will be in excess of $6,000,000. This total does not wholly represent those of the area between the state lines, as such reduction concerns as the American Smelting and Refining Co. are not represented.

A NEW RUBBER PRODUCER has been discovered in Portuguese West Africa. This plant, known by the natives as "ekanda" and "marianga," is the first tuber from which rubber has been extracted. It is the subject of a report by Prof. Carl Eugenio de Mello Geraldes, of the Agronomical Institute, Lisbon, Portugal. Portions of this report appeared in the "India Rubber World" of July 1.

It is stated that this plant is a stemless biennial, with a fleshy yellow tuberous root, sometimes turnip shaped, most frequently resembling a flattened sphere. The entire root is permeated with lactiferous ducts. Rubber has been obtained by several crude experimental processes, which consist usually of slicing and pressing the roots. The milky fluid obtained coagulates with alcohol but not with alum. The quality of the rubber so far produced is not first class.

Tubers two years old attain a diameter of 5½ ins., a weight of 1½ lbs. and a yield of rubber about ½% of total weight. Professor Geraldes regards the plant as adapted to cultivation and has figured estimates of yield and profit. He regards as possible a product of 188 lbs. of rubber per acre.

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Ought the engineering profession to have a formal code of ethics? This is a question which has been periodically agitated for a score of years or more and on which all shades of divergent opinions are held. As recorded in our last week's issue, the youngest of the four great national engineering societies—the American Institute of Electrical Engineers—is the first to formally draft such a code; and it was reported to the membership at the recent Niagara Falls convention. It was not adopted by the Institute, because under the constitution such action could not be taken at a summer convention; but it was referred back to the drafting committee for revision and submission to the governing body of the Institute. In view of the criticism the code received at the convention, it is likely to receive radical amendment before final adoption; and it is even possible that opposition among the members to the adoption of any formal code may yet carry the day.

Whatever final action may be taken, this first attempt at a formal code of ethics for a national engineering organization will interest every engineer who has followed the long agitation of this subject, pro and con, in various societies; and we therefore print it in full in this issue.

We have frequently referred in these columns to the Employers' Liability Law of Great Britain, advocated by President Roosevelt in recent public utterances as a desirable forward step in relieving workmen from the burdens due to industrial accidents. We find in the May "Bulletin of the Bureau of Labor," issued by the Department of Commerce and Labor, a most interesting monograph entitled "British Workmen's Compensation Acts."

The original act, placing the burden of industrial accidents upon employers, was passed ten years ago, against strong opposition from both employers and labor organizations. Experience has proved, however, that the criticisms of the act made in the early years of its operation were ill-founded. A complete investigation of the working of the act was made three years ago, by a committee appointed by the Government, having among its members Sir Benj. Browne, of the Institution of Civil Engineers. This committee report showed such beneficial results to have accrued from the act, that it was decided by the Government to further extend the working of the system. Parliament therefore passed, on Dec. 21 last, a new act which has just gone into effect, on July 1, and which extends the benefits of compensation for industrial accidents to practically all workmen.

It is shown in this report that England and its colonies and the principal manufacturing nations of Europe have now put in force Workmen's Compensation Acts, leaving the United States as the only industrial nation in which the burden of industrial accidents is borne wholly by the workmen. The subject is one certain to be agitated with increasing vigor from this time forward; and those of our readers interested in it will do well to secure a copy of the Bureau of Labor's report.

A notable departure in the conduct of insurance business is about to be undertaken in Massachusetts, viz., the conduct of industrial insurance by savings banks.

As most of our readers are aware, the business of industrial insurance is carried on in a most expensive manner. Investigations have shown that of the total amount of assessments paid by those insured in even the most honestly managed industrial insurance company, nearly 40% is expended in conducting the business. In Massachusetts savings banks, on the other hand, the expenses of management are only 1.47%. The safety of the deposits is guarded by strict legislation covering the class of securities in which funds may be invested.

That industrial insurance fills a great need for the workingman or woman who lives from hand to mouth and never accumulates enough to meet the emergencies of sickness and death that come to every household, has been fully demonstrated. Hereafter it will be possible for residents of Massachusetts who desire cheap industrial insurance to obtain it at actual cost, and the cost will not be swelled by the huge expense of the agents who solicit the insurance for companies and collect the 10 cts. a week assessments.

A correspondent sends us an advertisement for proposals reading as follows:

Baltimore, June 3, 1907.

Proposals will be received by the Board of Awards of Baltimore City to erect a building, to be known as Shop Building No. 1, at Baltimore City Jail for the Mayor and City Council.

Perhaps the writer of the above advertisement had in mind recent events at San Francisco.

THE WASHINGTON TYPHOID REPORT.

By a sort of Scotch verdict of "Not proven," the Washington water filtration plant is freed from the accusations of being a colossal failure because its installation was not followed during 1906 by a marked reduction in the high typhoid fever mortality which has long prevailed in Washington. This verdict we find by implication in the exhaustive report on "The Origin and Prevalence of Typhoid Fever in the District of Columbia," dealt with at some length elsewhere in this issue.

The Commissioners of the District of Columbia, on June 21, 1906, requested the U. S. Public Health and Marine-Hospital Service to investigate the continued prevalence of typhoid fever in Washington after the filtration plant was put in operation. In their request the Commissioners stated that the local Health Department had been unable to ascertain why typhoid fever continued, and added that the limited facilities of the Health Department made desirable the co-operation of the Marine-Hospital Service. A few weeks after this request was received, Dr. Walter Wyman, Surgeon-General, advised the Commissioners that as a result of preliminary investigations it seemed desirable that householders should boil all drinking water from the public supply. While this may have been a very wise precautionary measure, it nevertheless threw immediate suspicion, or increased that already existing, on the efficiency of the sand filtration plant which had been put in full operation in October, 1905.

After more than half a year of exhaustive study of typhoid fever cases in Washington occurring between Oct. 1 and Nov. 1, 1906, and after many lines of collateral investigation, the board of inquiry delegated to the task on behalf of the Public Health and Marine-Hospital Service came to the conclusion that of 866 cases studied 10% were due to typhoid-infected milk, 15% were imported, and 6% were due to personal contact. The origin of the remaining 69% was left in doubt. The tenor of the report, however, seems to indicate that, while unwilling to say so, the investigators still believe that the filtered water supply is under suspicion. We hasten to add that the report from beginning to end shows a desire to be impartial.

We think the consensus of opinion among engineers and sanitarians competent to judge will be that the data given in the report confirm in the main the conclusions set forth by Mr. Theodore Horton, M. Am. Soc. C. E., and Prof. William T. Sedgwick in our issue of Nov. 8, 1906. These were that other causes than the public water supply were responsible for the continued high typhoid mortality in Washington. These causes are confessedly difficult of assignment by even approximate distribution percentages. In general, they are included under the term "residual" typhoid, introduced some years ago by Professors Sedgwick and Winslow to denote the typhoid fever remaining in a community after the introduction of an improved water supply.

The recent Washington investigations have been unique in that they deal not with epidemic conditions but with long-continuing high typhoid mortality. Under such circumstances an investigation resulting in specific conclusions as to causes is involved in many difficulties. A sudden outburst of typhoid, like those at Plymouth, Ithaca, Butler and Scranton, is traceable to its origin with comparative ease because there is usually a single great cause for the outbreak. But it is becoming more and more evident, as studies of the Washington situation proceed, that in a number of our American cities, particularly those of the South, there are many sources of typhoid infection, some of which are not readily found and all of which together make up a large number of cases and deaths. The difficulties of investigations under such circumstances are increased by the general lack of knowledge of the governing conditions. At Washington, we are pleased to say, the Health Department for several years past has put itself in possession of the greater part of the purely local information regarding the environment of cases previous to infection, so that the more elaborate investigation just made really covered very much the same ground as had already been gone over, a finer rake, so to speak, being used for the collection of local evidence. The Marine-Hospital Service, however, had laboratory facilities at its disposal, which were unfortunately quite lacking on the part of the Health Department, and it was also able to go further afield in several directions. Nevertheless, the net result of this exhaustive investigation really adds very little, so far as we can see, to the broad general working knowledge which the local Health Department possessed at the outset. The health authorities, it is true, are now armed with more detailed information than they possessed before regarding the unsanitary conditions under which a very large percentage of the milk supply is produced and distributed, and also regarding the suspicious character of the shallow public wells still remaining in the District, notwithstanding the efforts of the Health Department to close them. The investigations also emphasize the importance of more care being taken in the sick-room to prevent the spread of typhoid to other members of the family and to outsiders as well. Further, and of more importance, perhaps, the report indicates the need of not only a continuation of the detailed study of all typhoid cases, but also an extension of cause-investigations to include detailed particulars of possible infections of other foods and drinks besides milk and water. In particular, it

seems desirable that the fruit and vegetable supply of Washington be studied at its sources, in so far as these foods are eaten raw, and also that similar studies be made of shellfish.

In debiting 10% of the typhoid cases to the milk supply, 15% to importations and 6% to contact, it should be remembered that cognizance is taken of those cases only which the evidence seemed to prove were directly attributable to the causes named. This is of course perfectly proper as a matter of routine investigation and precise summary of results; but in view of all the uncertainties involved in inquiries of this kind, and of the lack of precise knowledge bearing upon the points at issue, it would seem quite proper to generalize somewhat in a final summary and to multiply these percentages by probable factors of error and omission. We will not attempt to say what these factors might be, but it seems to us certain that the reasonably well-known contact cases, for instance, might in a final summary be materially increased to make allowance for the percentage of contact cases that must have escaped discovery.

In the tables of analyses of shallow well waters, we note that a number of wells were classed as suspicious and yet the origin of cases known to have drunk water from these wells was classed as uncertain, even where as many as six cases had used water from a single well. While we agree with the board of inquiry, in the light of the evidence presented, that the shallow wells in the District of Columbia do not account for the prevalence of typhoid fever there, yet it does seem that in such a general summary as we have just been discussing a few of the cases might very properly be charged against the well. This, however, is a matter of comparatively little importance.

The marked excess of typhoid among negroes and among children seems worthy of future detailed investigation. The excess can by no possibility be attributed to the public water supply unless it can be proven that negroes and children are both more susceptible to typhoid than white people and adults, so that, typhoid germs being in the water, their effect would be reflected in the vital statistics. So far as children are concerned, we believe it is generally understood that they are freer from typhoid than adults; but in the case of typhoid due to milk, it is common to find a large number of cases and deaths among children.

Two very interesting lines of study made by the board of inquiry deserve special mention. One of these had to do with "typhoid bacillus carriers," and while it merely reviewed the literature of the subject, it is very suggestive, indeed, in its possible bearings upon the dissemination of typhoid, not alone in Washington but throughout the world. Several instances are cited in the report, of single individuals who for years had retained typhoid germs in their systems and had doubtless been the cause of many cases. Some of our readers will remember that in our issue of May 23, 1907, we published an abstract of a paper by Dr. George A. Soper relating to a woman who is believed to have been the cause of at least 26 cases of typhoid within five years, the facts for two of the five years being unknown. Of course there is no reason to suppose that Washington is inflicted with any more of these typhoid carriers than any other city in the country.

The other particularly interesting line of investigation which we had in mind was designed to prove or disprove the recently-advanced theory that intestinal worms are an important factor in typhoid infection. Although 200 patients were studied from this point of view, the results were negative.

In our article elsewhere in this issue we have quoted quite extensively from the report a summary of the reasons for and against the belief that the Potomac River water after storage and filtration is responsible for the continued prevalence of typhoid at Washington. It is unnecessary for us to restate these arguments here. We think the board is to be commended for having presented both sides of the case so fully. We would call especial attention to the relatively small amount of pollution of the Potomac River above the water-works intake, and the great dilution which this small amount of pollution receives from a drainage area of 11,400 sq. mi.; also, to the long period of sedimentation (not particularly emphasized in the report) to which the water is subjected; and also (not mentioned in the report, we believe), to the fact that although the colon bacillus has been found in the filtered water at Washington, it is reduced proportionately with the total bacterial content.

We think it would have been profitable if more attention had been given to the causes or probable causes of high typhoid mortality in other Southern cities than Washington. As will be seen from the figures which we reproduce elsewhere, typhoid in other Southern cities during a recent five-year period has shown an average range of from 45.22 per 100,000 for Memphis, Tenn., to 99.22 in Lynchburg, Va., as compared with 63.2 for Washington for the five-year period and 49.3 for 1906 (a year not covered in the average). Although the report cites the fact that Winnipeg, Manitoba, with a water supply said to be from artesian wells and to be very pure, nevertheless has a high typhoid rate, we have found no reference in the report to the fact that Memphis, with the lowest average in the table just mentioned, has for years drawn its supply from deep-seated waters which, so far as we know, are entirely above suspicion. And yet, although Memphis is the lowest in the list of Southern cities cited, its average typhoid mortality for five years is over 45 per 100,000, or 2¼ times the one-time accepted rate for cities with a pure water supply, and nearly as high as the Washington rate for the year 1906. Certainly, as we have suggested, the facts back of this line of statistics are worthy of pursuit.

We should feel that a duty had been left unperformed did we not call attention to the shameful condition of the milk supply of our national capital. Carelessness and negligence in the most obvious precautions for the production of safe milk, bacterial milk counts running from 1,000,000 to more than 300,000,000 per c. c., and typhoid among milk handlers or their families, were found by the board of inquiry. Some of these evils the local health department has no legal authority to prevent. And yet, if we are correctly informed, another session of Congress ended without action for removing such grave evils, and without providing means for a laboratory in which the health department can study its milk and water problems.

When it is remembered that nearly all that money and modern sanitary science can do has been done to purify the public water supply of Washington it seems only fair and reasonable to relieve it of suspicion until all that is known by public sanitarians has been done to guard other avenues of infection, particularly the milk supply. Of course we do not mean that the possibilities of infection by filtered water should be overlooked; nor do we mean to say that milk is more, or much more, directly responsible for typhoid in Washington than the report indicates. It may well be, however, that dirty and bacteria-laden milk, as a predisposing cause, is indirectly responsible for a considerable part of the high typhoid mortality among children, while of course no one questions its baneful effect upon infant life and child life in general.

What we do wish to emphasize is that of the many possible avenues of typhoid fever in Washington, the public water supply is the only one thus far under anything like adequate sanitary control.

In conclusion, we think it will be evident to all who study this valuable Washington report that there is yet a very great deal to be learned regarding the origin and prevalence of typhoid fever, both in Washington and in other cities of the country where the mortality rates have been persistently high for a long series of years. Most of the other cities are not blessed with as efficient a health department and with as excellent a water supply as Washington now possesses, and no other city has in its midst a branch of the national government with ten men at command to assist for months in the study of its typhoid problem. All the more need, therefore, for the reorganization of their health departments, the improvement of their water supplies and a search after the cause of typhoid and other preventable diseases which are yearly reaping their thousands upon thousands of victims.

LETTERS TO THE EDITOR.

More on Flat-Plate Theories as Applied to Reinforced Concrete Slabs.

Sir: In your issue of June 20 the writer notes a letter from Mr. Edward Godfrey relative to a communication concerning slabs, in which the writer made a statement regarding the strength of slabs reinforced in two ways and showing only that the distance of the center of gravity of the load carried to the supports by a slab supported on four sides was but two-thirds as great as in the case of the same square slab supported on two edges. Mr. Godfrey seems to confuse this fact with the question of proof of the statement and asserts that the method given by the writer is not conclusive. The method of proof clearly recommended by the writer in this letter is to test the slab by actual load and find out what it will carry without injury or exceeding a reasonable deflection. This method of proof may not seem conclusive to the theorist, but is generally found satisfactory by the contractor who has to guarantee the strength of the construction under a test load with a maximum deflection, as it involves the fewest assumptions.

Mr. Godfrey further states that the critical part of a square slab is at the center of the square. He offers this as an assertion without demonstration or experimental proof. What data has he for making the assertion? It would unquestionably interest those who have done any work in the line of testing slabs reinforced in two ways. The writer is not a theorist and takes interest in the theoretical analysis of reinforced concrete to the extent which it may enable the constructor to more readily put up work which he can guarantee. His suggestion as to the flat-plate theory was along the line of accounting more readily for the demonstrated strength of work as indicated by actual tests.

Mr. Godfrey states that the flat-plate theory is objectionable because a flat plate is subject to tension in all directions near the bottom and concrete cannot be counted on to take tension and the rods cannot be placed in all directions. Apparently Mr. Godfrey forgets to apply the principles of elementary mechanics by which forces in various directions can be held in equilibrium by rods or ropes which do not run in the same direction as the forces. For example, we have the case of the ordinary boom derrick, the head of the mast of such a derrick being subjected to lateral forces in any direction whatever, held in equilibrium frequently by four guy ropes running at right angles to each other. The simple resolution of forces enables a practical solution of this problem. In the slab, assuming that we have tension in all directions at the bottom, we have the bars, if reinforced in two directions, running at right angles to each other and why should we not apply the same principle involving only the reasonable and normal assumption of the actual adhesion of the concrete to the bars an assumption upon which is based the analysis which Mr. Godfrey recommends?

Respectfully yours,

C. A. P. Turner.

Minneapolis, Minn., June 22, 1907.

The Late Wm. F. Shunk.

Sir.—Permit me to say in a not unfriendly way that I think it is far from creditable in a publication of the field and standing of Engineering News to note the passing away of such masters of the engineering profession as Wm. F. Shunk with such a scrimpy and incomplete obituary notice as that on Mr. Shunk in your current issue. He was one of the finest characters, one of the grandest men and one of the very best engineers the profession has ever been graced with. I doubt if any other ever so instilled in his younger associates the finer attributes of his own character.

Yours truly,

T. H. Loomis.

Steubenville, Ohio, June 28, 1907.

[We well appreciate that our hastily prepared note was all too inadequate for a man of Mr. Shunk's reputation and qualities. But we may add that a former member of our editorial staff who was a personal friend of Mr. Shunk repeatedly tried to obtain from him a photograph and material for some sketch of his long and important professional career. To all these requests Mr. Shunk returned a steady refusal, insisting that his personality was too unimportant for notice in any engineering publication. We are glad to give space to the tribute which Mr. Loomis pays to Mr. Shunk's high qualities, and

many of those associated with him, we are sure, could testify as to its accuracy.

Since the above was in type we have received another tribute to Mr. Shunk's memory, which we print below. It is surely a far finer revelation of his personal character than any obituary that we could frame.—Ed.]

Sir:—The notice of the death of William Findlay Shunk, while not unlooked for to those who have known of his state of health, must be a sorrow to the many that have known and admired him. I never had the pleasure of meeting him, though I have long been among his admirers, and feel that I cannot let the occasion go by without giving the following extract from a letter to myself, written years ago, as it seems to me to show the kindly nature of the man as no words from another could. O. H. Tripp.

Rockland, Maine, July 1, 1907.

"Mr. O. H. Tripp, Civ. Eng'r,
"Rockland, Maine.

"Dear Sir: The newspaper containing a notice of your father's death is also to hand. Nature must needs feel the hurt of parting, but indeed there is little to grieve for in such a departure. He was gathered 'like a ripe shock of corn in its season'—has cast all infirmities and now resumes the vigor of youth, a vigor immortal. Just so went my mother some years ago, at nearly the same age. Mr. Tripp, the mothers and fathers we have known, the brothers, sisters, cousins, friends, etc., of our nearer communion, being in almost every case such good people, as we every one of us know—then the inference is that the human creature is a better creature all the world over than cynics, pessimists and sometimes theologians are willing to rate him. I can speak from an experience in all the continents and many of the islands of this world—from the clouted savage to the New York dude—and my experience is that man is a goodly creature and naturally tends upward.

"Yours very truly,
"Wm. F. Shunk."

Harrisburg, Pa., April 3, 1894.

Pile Foundations for Tunnels in Soft Ground.

Sir:—In your issue of June 27 you describe a method of constructing concrete pile foundation under the East River at the Battery. I have given a good deal of thought to the subject of foundations for railway tunnels in soft ground, and I have submitted the plan of construction shown in the enclosed drawing to the Pennsylvania R. R. Co. for application to their Hudson River tubes.

In my opinion, this plan can be applied with equal facility to the Battery tunnel. The pairs of concrete piles, 50 ft. apart, which you describe, are all very well as far as they go, but in my opinion there are not enough of them, and there will be as much vibration in the middle of the span as if they did not exist. I therefor suggest the advisability of making practically continuous pile support for the tunnel by driving down wooden piles in the manner herein described.

With your permission I will make the description of my plan apply to the Pennsylvania R. R. tunnels, as this subject is of considerable interest to engineers, and the plan has equal application to both tunnels.

It is well known that a plan for supporting the road bed upon cast iron screw piles has been contemplated by the Pennsylvania R. R. for its Hudson River tunnels. The screw piles proposed are 5 ft. in diameter at the screw and 27 ins. at the shaft, and spaced in single file 15 ft. apart from center to center along the line of the tunnel. It is proposed to put them down by a machine operated by hydraulic pressure, which at the same time that it rotates the pile also presses down upon it with enormous force. It is my opinion that the reaction upon the inside of the tunnel which will be required to rotate and force down a screw pile of such unprecedented proportions will have a tendency to force the tunnel out of line and may possibly cause disaster. This will be appreciated when it is remembered that the tunnel itself before it is lined with concrete has a theoretical tendency to move upward, due to the fact that its weight is only 15,000 lbs. per lineal foot, whereas the semi-fluid material it displaces weighs 43,000 lbs. per lineal foot, a buoyancy in the tunnel itself of 14 tons per foot. In the plan I have advocated the pressure required to force down a standard wooden pile will probably not exceed 20 tons, as compared with upwards of 100 tons for the screw pile previously tested by the Pennsylvania R. R.

The apparatus I suggest is illustrated herewith. Fig. 1 shows a sectional end elevation and Fig. 2 a sectional side elevation of my hydraulic pile driver in the act of driving the pile from within the tunnel. I propose to drive a pile 40 ft. long cut in two lengths, 20 ft. each, and strongly spliced together. The pile driver consists of a steel cylinder large enough to contain a 12-in. pile. This cylinder is provided with a trunnion, which enables it to be turned into the horizontal position as shown in the drawing. When in this position, the first 20-foot section of the pile is inserted and the cylinder is rotated back to its normal position. A pressure of 375 lbs. per sq. in. producing 25 tons total pressure is then exerted upon the short piston over the pile by an electrically driven hydraulic pump, and the pile is sunk to the proper depth. The second section of the pile is then spliced on and driven in like manner down on top of the first. The carriage containing the pile driver is so constructed that the hydraulic cylinder may be moved laterally so that two or more piles may be driven side by side in each bent.

It will not be a difficult matter to cut a circular hole in the thin cast iron shell forming the floor of the tunnel, and of course this hole would be permanently plugged by the pile and the concrete capping 2 ft. thick with which the tunnel is to be lined.

In order to locate the pile driver in the most convenient position for performing its functions I have designed an elevated timber platform, constructed along the middle line and on either side of the tunnel, to which are bolted a pair of heavy beams, which serve as tracks for the pile driver carriage.

The importance of designing a machine which will rapidly handle a heavy stick of timber, such as a pile, in the limited space found in the interior of a tunnel will be understood when it is stated that in this plan 7200 piles, 40 ft. long, would be required in the foundation of the two Hudson River tubes.

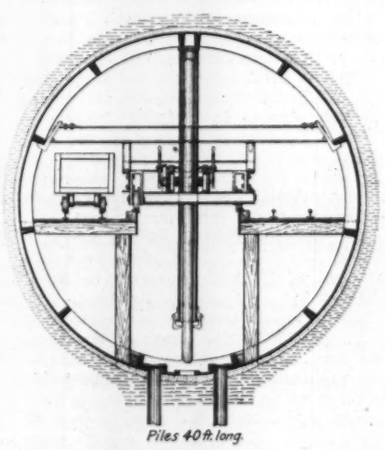

Fig. 1.

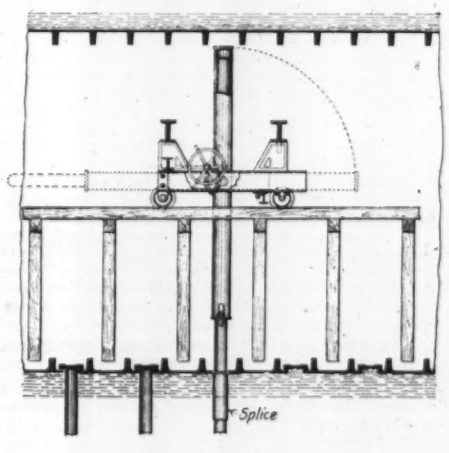

Fig. 2.

REACTION TRUSS FRAME FOR RENO HYDRAULIC PILE DRIVER.

An important feature of the side platforms is the space they provide for a pair of narrow gage railway tracks which serve the material cars so that the pile driver will not interfere with the passing of the cars loaded with concreting material. By this method a pile foundation can be constructed simultaneously with the lining of the tunnel with concrete, and a great saving of time will result.

It will be noted by reference to Fig. 1 that in order to distribute the upward pressure resulting from the force exerted upon the pile, two heavy I-beams are provided which extend across the tunnel and distribute the pressure over a large area of the roof. One of these beams is pivoted to the carriage and can be moved out of the way when the pile cylinder is rotated into a horizontal position.

By the method I have described it is practicable to put down nine or even eighteen wooden piles in lieu of one screw pile. Mr. J. A. Bensel, Chief Engineer of Docks, has made some very interesting tests upon the supporting power of wooden piles driven in 40 ft. of Hudson River silt (see Eng. News, May 18, 1905). His tests show that the piles I have proposed will support a load of 40 tons each. The Pennsylvania R. R. Co. will haul its trains through the tunnel with an electric locomotive weighing 105 tons, upon a wheel-base approximately 24 ft. long. Under this area the plan I suggest would provide twelve piles, and if we assume the supporting power of forty tons per pile, as stated by Mr. Bensel, we would have a total support of 480 tons under the locomotive.

It is of course obvious that piles could be driven under every segment, instead of under alternate segments, in which event the foundation would have a supporting power of 960 tons for a length of 24 ft. of tunnel. It is also obvious that when a pile is driven by my method it will be held absolutely straight for its entire length. Another point in favor of this plan is the fact, proved by actual test, that a pile can be forced down into the silt by a pressure of ten or fifteen tons, and after standing a few days, a pressure of forty tons will not move it.

J. W. Reno,
Mining Engineer.

555 West 33d St., New York City, July 1, 1907.

THE PROPOSED CODE OF ETHICS FOR THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

In our report of the Niagara Falls Convention of the American Institute of Electrical Engineers, published last week, we noted the presentation of the report of the committee appointed a year ago to draft a code of ethics for the Institute. As we then stated, the meeting got into a parliamentary tangle in the discussion of the proposed code and action for its adoption was therefore deferred for the present.

There has been so much interest and discussion for a score of years past concerning the general subject of ethics for the engineering profession that we have deemed it worth while to print the committee's report in full, as follows:

PROPOSED CODE OF ETHICS FOR THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

To the President and Board of Directors of the American Institute of Electrical Engineers.

Gentlemen: Your committee, appointed at the annual convention at Milwaukee in June, 1906, to consider the advisability of preparing a code of engineering ethics, and, if thought best, to prepare such a code, has to report as follows:

While we do not consider it practicable at this time to formulate a code of ethics covering explicitly all the conditions which the electrical engineer may meet in his work, we do consider it both practicable and desirable to record some of the general principles of professional conduct that should be a guide for the electrical engineer, leaving it to him to make specific application to the cases which he may meet. We therefore submit and recommend the following, to be printed and distributed to the membership, with a view to its discussion and adoption at the approaching Annual Convention in June, 1907.

Respectfully submitted,
Charles P. Steinmetz, Harold W. Buck, Schuyler Skaats Wheeler (Chairman).

Ampere, N. J., May 17, 1907.

PRINCIPLES OF PROFESSIONAL CONDUCT FOR THE GUIDANCE OF THE ELECTRICAL ENGINEER.

A. General Principles.

B. Relations of the electrical engineer to his employer, customer or client.

C. Relations of the electrical engineer to the ownership of the records of his work.

D. Relations of the electrical engineer to the public.

E. Relations of the electrical engineer to the engineering fraternity.

F. Relations of the electrical engineer to the standards of his profession.

A.—GENERAL PRINCIPLES.

1. In both his professional and his business relations the electrical engineer should follow strictly the same ethical principles that are recognized in the social relations of every-day life. He should consider himself personally responsible for the character of the enterprises and the persons with which he is associated professionally.

2. Before entering into professional relations it is, therefore, the duty of the electrical engineer to satisfy

himself that the enterprises with which he connects himself are of a legitimate character. If, after becoming associated, he finds them to be of a questionable nature, he should sever his connection as soon as possible. It should not be considered an excuse that his connection extends only to legitimate engineering work.

3. An electrical engineer permitting the use of his name in any enterprise or exploitation becomes morally responsible for the character of the latter. He should, therefore, not allow the use of his name in connection with anything upon which he is not qualified by training and experience to exercise competent judgment.

4. The electrical engineer should take care that credit for engineering work is attributed to those who, as far as his knowledge of the matter goes, are the real authors of such work.

5. The electrical engineer should incline toward, and not away from, standards of all kinds, since standardization is peculiarly essential to the general progress of the profession. This applies to construction, measurement and expression, or nomenclature as well as to conduct, or ethics. Even the tendency to give individuality by providing special construction may sometimes be avoided with advantage.

B.—RELATIONS OF THE ELECTRICAL ENGINEER TO HIS EMPLOYER, CUSTOMER OR CLIENT.

7. The electrical engineer should consider the protection of his client's interests as his first obligation, and therefore should avoid every act that would be contrary to this duty; if any other consideration, such as professional obligations or restrictions, interfere with his so acting, in accordance with the expectation of his client, he should inform him of the situation.

8. He can honorably accept compensation, financially or otherwise, from one side or party only interested in the same matter. The electrical engineer, whether consulting, designing or operating, may, therefore, not accept commissions, either directly or indirectly, from other parties dealing with his principles.

9. Electrical engineers in a position to decide on the use of inventions, apparatus, etc., should not be financially interested in their use, as by receiving a royalty, etc., unless the matter is clearly understood by the client.

10. Electrical engineers should not accept employment while financially interested in a rival concern except upon the express permission of both parties. An electrical engineer may be employed by more than one party, as in the case of a consulting engineer, when the interests of the parties do not conflict, and it is understood, as is usual in such cases, that he is not expected to devote his entire time to the work of one party, but is free to enter into other engagements. A consulting engineer permanently retained by a party should notify other prospective employers of his affiliation before entering into relations with them. A consulting engineer when not exclusively retained by one side may advise rival concerns, with the full knowledge of all of them, and upon taking care that the interests of the parties do not conflict in the particular matter handled.

11. Operating engineers should consider themselves responsible for defects in apparatus or dangerous conditions of operation; should bring the same to the attention of their employers and urge remedial action. If the causes of the danger are not removed they should withdraw.

12. An electrical engineer should in general be considered directly responsible to his employer or client for the successful fulfilment of the work upon which he has been engaged and for its satisfactory performance as a whole. It should therefore be clearly understood at the outset just what the extent or the limitations of responsibility of the engineer are to be—whether he has been employed merely as designer, or whether he is retained to design and superintend construction; whether to design only the chief features, or to pass as well upon all details of the apparatus that is to be installed. Attention should be directed to the fact that defects in the manufacture of material or apparatus is a matter distinct from the matters of design or installation. An engineer should not be held responsible for the unsatisfactory performance of a plant resulting from defective apparatus furnished unless he has undertaken to include this subject.

C.—RELATIONS OF THE ELECTRICAL ENGINEER TO THE OWNERSHIP OF THE RECORDS OF HIS WORK.

15. The following general principles should be recognized:

If, in executing his work, the electrical engineer uses data or information which are not common and public property, but which he receives, directly or indirectly, from his employer, or if the problem solved by the engineer is met in the pursuit of his work for his employer, and is not of such character that his attention would have been directed to it regardless of his relations to his employer, the products of his work, in the form of inventions, plans, designs, etc., are not his private property, but the property of his employer, though the engineer may be entitled to special remuneration for such inventions, etc.

16. If in the execution of the work the engineer uses only his own knowledge or data or information, which are public property by prior publication, etc., and receives no engineering data from his employer or customer, except performance specifications, the results of the work, such as inventions, plans, designs, etc., are the private property of the engineer, and his employer or customer is entitled to their use only in the specified case.

17. All the work done by the engineer in the form of inventions, plans, designs, etc., which are outside of the field of engineering for which his employer has retained him are the engineer's private property.

18. When an engineer or manufacturer builds apparatus from engineering designs supplied to him by his customer the designs remain the property of the customer and should not be duplicated for other customers without express permission. When the engineer or manufacturer and his customer are jointly to work out designs and plans or develop inventions, a clear understanding should be arrived at before the beginning of the work regarding the proportionate rights of ownership in any inventions, designs, etc., that may result, since in such case both parties should be considered to have rights therein.

19. Any engineering data or information which an electrical engineer obtains, directly or indirectly, from his employer or customer, or which he creates as a result of such information, must be considered by the engineer as confidential; and while the engineer is justified in using such data or experience in his own practice as going towards his education, the publication thereof without express permission is improper, as is also its use in producing for other parties work that is characteristic of the original customer or employer.

20. Designs, data, records and notes made during his engagement by an engineer employed under permanent engagement, and referring to his work, are his employer's property. The same matter in the case of a consulting electrical engineer are the property of the consulting engineer.

21. A customer, in buying apparatus, does not acquire any right in its design beyond the use in the apparatus purchased. A customer of a consulting engineer does not acquire any right to the plans made by the consulting engineer except for the specific case for which the apparatus was built or the plans made.

D.—RELATIONS OF THE ELECTRICAL ENGINEER TO THE GENERAL PUBLIC.

22. The electrical engineer should endeavor to assist the public to a fair and correct general understanding of engineering matters, spread the general knowledge of electrical engineering, and discourage wrong or exaggerated statements on engineering subjects published in the press or otherwise, especially if these statements are made for the purpose of, or may lead to, inducing the public to participate in unworthy schemes.

23. Controversies on engineering questions, however, should never be carried on in the public press, but should be confined to the technical press and the engineering societies.

24. First publication of inventions or other engineering advances should not be made through the public press, but rather through the technical press and the engineering societies.

25. The publications which an electrical engineer is justified in making through the public press should therefore be of a historical, educational, instructive or similar character, and should not relate to controversies between engineers or on engineering questions, to new inventions, etc., nor contain technical criticisms of fellow engineers, and it should be considered unprofessional to give opinions without being fully informed on all the facts relating to the question, and on the purpose for which the opinion is asked, with a full statement of the conditions under which the opinion applies.

26. In giving expert testimony before judicial bodies the electrical engineer should confine himself to brief and clear statements on engineering or historical facts. He should not give personal opinions without so expressly stating, and should avoid pleading on one side or the other.

E.—RELATIONS OF THE ELECTRICAL ENGINEER TO THE ENGINEERING FRATERNITY.

30. The electrical engineer should take interest in and show due regard for the electrical engineering societies and the technical press.

31. He should assist his fellow engineers by exchange of general information, experience, instruction, etc.

32. He should not take a position left by another electrical engineer without satisfying himself that the former has left it voluntarily or for proper reasons.

33. Where engineering work is in charge of an electrical engineer, no other electrical engineer should undertake the work except on request of or in cooperation with the electrical engineer who had charge of the work before, unless the latter's connection with it has already terminated.

34. An electrical engineer in responsible charge of work should not permit other engineers or non-technical persons to overrule his electrical engineering decisions. If this is done, and persisted in, he should, as soon as is practicable, withdraw.

35. In engineering work in charge of a board of engineers the respective limitations of the authority of each should be decided at the outset, and each electrical engineer should give full and complete information on his part to the other engineers and insist on this being reciprocated.

F.—RELATIONS OF THE ELECTRICAL ENGINEER TO THE STANDARDS OF HIS PROFESSION.

40. The title "electrician" should be applied to those having practical training sufficient to enable them to carry on intelligently certain classes of electrical work, such as the installation of electric lights, signal systems and the operation of small electric plants.

41. The title "electrical engineer" should be applied only to graduates from the electrical engineering schools of universities of recognized standing, and such men as possess an equivalent knowledge of electrical engineering.

42. The title "consulting electrical engineer" should be applied only to those electrical engineers who possess such knowledge and experience in electrical engineering as would qualify them to full membership in the American Institute of Electrical Engineers.

(Signed)

Charles P. Steinmetz, Harold W. Buck, Schuyler Skaats Wheeler (Chairman).

OFFICIAL REPORT ON TYPHOID FEVER IN WASHINGTON, D. C., IN 1906.

The most comprehensive and extensive report on a typhoid fever investigation ever yet made has just been published by the U. S. Public Health and Marine-Hospital Service. The report deals with "The Origin and Prevalence of Typhoid Fever in the District of Columbia."* The investigation was made at the request of the Commissioners of the District of Columbia, on account of the fact that typhoid fever at Washington increased after the new water filtration plant was put in operation, instead of decreasing as was expected. Surgeon-General Walter Wyman detailed a "board of officers" to meet July 2, 1906, for purposes of investigation, as follows: M. J. Rosenau, Director Hygienic Laboratory, Chairman; L. L. Lumsden, Passed Assistant Surgeon; and Joseph H. Kastle, Chief of the Division of Chemistry. The latter acted as recorder. Later seven other "officers of the laboratory" took part in the investigation. The manuscript of the report was submitted on Feb. 16, 1907. The study included, among other things, a house-to-house investigation of the 866 cases of typhoid fever reported between June 1 and Nov. 1, 1906. Consideration was also given to milk and other dairy products, ice, public wells and springs, table waters, the water supply of the district, sanitary condition of residences, fruit, vegetable and shellfish supplies, and the sanitary conditions of the whole Potomac River drainage basin. In addition, the literature of typhoid "bacillus carriers," of the longevity of the typhoid germ outside of the human body, and "The Alleged Role of Intestinal Worms as Inoculating Agents in Typhoid Fever," was reviewed. Laboratory studies of the last-named subject were made in Washington.

As many of our readers will remember, a special investigation of typhoid fever in Washington was made for this journal some months ago by Mr. Theodore Horton, M. Am. Soc. C. E., Consulting Engineer of the New York State Department of Health. A report by Mr. Horton, followed by a discussion by Prof. William T. Sedgwick, was published in Engineering News of Nov. 8, 1906. The object of Mr. Horton's report was to place before our readers the facts and probabilities regarding typhoid in Washington from an engineering point of view. This seemed particularly desirable in view of statements in the daily press and private conversation to the effect that the continued prevalence of typhoid in Washington was a proof that the filtration plant there was a failure. The conclusions of both Mr. Horton and Professor Sedgwick were that such allegations were entirely unfounded and that responsibility for the large amount of typhoid then prevailing rested upon a great variety of causes other than the Potomac water supply, including the milk supply, vegetable and fruit supply, shellfish, public wells, open privies, and direct infection by personal contact.

*Hygienic Laboratory. Bulletin No. 35, M. J. Rosenau, Director. February, 1907. Address Public Health and Marine-Hospital Service, Washington, D. C.

The specific conclusions of the board of inquiry, as summarized in the report before us, are as follows:

> During the period covered by our investigation we found that about 10% of the cases were attributable to infected milk; about 15% of the cases were imported; about 5% of the cases were traceable to "contact." This accounts for about 30% of the 866 cases studied.

As will be seen, this leaves unaccounted for some 70% of the large number of cases studied.

VARIOUS FACTORS.—It appears from the report that the large number of negroes in Washington is in part responsible for the excess of typhoid fever there. This is mentioned in more detail near the close of this article.

A notable feature of the 866 cases investigated was the large number occurring in children under the age of 15. The report states:

> This makes it probable that many cases are not recognized, as typhoid is especially mild and irregular in children. The prevalence of the disease among children may have an important bearing upon the subject of the spread of the disease by direct and indirect contact.

The seasonal prevalence of typhoid during 1906 was similar to that of other years, the maximum occurring early in August.

The cases were quite uniformly distributed throughout the District, but in the Government Hospital for the Insane, with a population of about 3,000, and with a water supply from artesian wells, there were no typhoid cases reported during the whole year 1906.

Careful tallies on such matters as the screening of houses, the abundance or relative absence of house flies, the number of mosquitoes, ants, roaches, bedbugs, rats or mice, and the number of dogs, cats, horses, cows, goats, chickens, canary birds, and various other animals and pets, seemed to show that these had no relation whatever to the occurrence of typhoid cases.

Unfortunately, as it seems to us, no definite conclusion "can be made concerning the relation of" fruits and vegetables to the disease "on account of the difficulties in obtaining accurate information regarding the sources" of these food supplies. The members of the board state as their "impression" that fruit and vegetables "played little or no part in the spread of the infection." The same general conclusion was reached as regards shellfish and fresh-water fish, but this conclusion was based on far more definite information. A very large proportion of the patients ate neither oysters, clams nor lobsters within 30 days prior to their illness; only a third or so having eaten crabs, and about a half, fresh-water fish.

BEDSIDE DISINFECTION.—Of the 866 cases, no less than 374, or 43.18%, were treated in hospitals, thus diminishing "the chances of dissemination of the infection," as did also the care of 119 additional cases by trained nurses. The report states:

> Of the 492 cases treated at home, the use of disinfectants in stools and urine was found to be efficient for 145 cases, inefficient for 286 cases, of doubtful efficiency for 51 cases, not stated for 10 cases.

Other precautionary measures, such as the treatment of the linen, dishes, etc., of the patients, were fairly efficient in 212 cases, inefficient in 270 cases; not stated in 10 cases. The report states that, in the opinion of the board, attending physicians should be held responsible for the destruction of typhoid infection as it leaves the body of the patient; that this is evidently not the case in Washington; and that "if this condition of affairs cannot be corrected voluntarily" then "its enforcement by legislative enactments" is recommended.

MILK SUPPLY.—Responsibility for about 10% of the cases, as has already been stated, is placed upon the milk supply. Some 25 pages of the report are devoted to the milk supply. This section, it seems to us, is, or would be if its teachings were heeded by the Washington authorities and by Congress, by far the most valuable in the whole report. Most of the dairies investigated showed gross dirtiness and carelessness. Bacterial counts of the milk from some dairies showed a large number of samples with from 1,000,000 to 100,000,000 bacteria per c. c., while a few ran over 200,000,000 and one contained 308,000,000. Three distinct milk outbreaks of typhoid during the period under investigation were studied.

Only 3 out of 38 dairies inspected claimed to sell milk of their own production exclusively. The washing of bottles and dairy utensils was as a rule very inadequately done. Milk handlers showed "a woeful disregard of cleanliness as it is understood in a sanitary sense," while two instances were found "of employees living at homes in which cases of typhoid fever were being treated." Some of the worst conditions noted appertain to corner stores where milk is sold in small quantities. These stores, "while subjected to inspection," are immune to the general sanitary requirements of the "Health Department" owing to "a technicality in the law." On this general subject the report may be quoted as follows:

> In some instances we found small grocery stores selling a cent's worth of milk from bottles or cans, while upstairs or in an adjoining room typhoid fever cases were being treated. The same hands that cared for the sick dispensed milk. Flies passed freely from the sickroom to the store, and the chances of conveying the infection from the patient to milk and other articles sold in the store were favorable.

TYPHOID BACILLUS CARRIERS.—Next to the section of the report on the milk supply, perhaps the portion dealing with "typhoid bacillus carriers" is the most suggestive. It contains nothing specific as regards typhoid in Washington, but sets forth with considerable particularity a number of apparently well-attested cases where persons have harbored typhoid fever germs in their systems for many years and have infected many other people.

INTESTINAL WORMS IN RELATION TO TYPHOID.—An original and somewhat novel study made by the board was designed to test the "theory advanced by Guiart, that intestinal worms, especially whipworms, commonly play an inoculating role in typhoid fever somewhat similar to the role played by fleas in bubonic plague." To test this theory, 200 typhoid cases were selected at random and their faeces were examined for intestinal worms. The results did not give any support whatever to Guiart's theory.

WELL WATERS.—Careful studies of public well waters were made by the board. These indicated that of the 87 public wells used for drinking purposes in the district, the 24 deep wells were "of excellent quality, both chemically and bacteriologically;" but of the 63 shallow wells, 31 showed indications of sewage pollution, 29 were suspicious, and only 3 gave no evidence of pollution. The typhoid case studies showed from one to a half-dozen patients who had used some of these wells; but the board did not connect any of the cases with the wells, leaving most of these in the unknown-origin class. The board recommended that all the shallow wells be closed.

It may be noted in passing that the Health Department of the National capital is without a laboratory for analytical work connected with the study of well-waters, etc.

TABLE WATERS.—The study of commercial table waters, while not throwing any direct light upon typhoid in Washington, nevertheless showed that some of the water sold, and presumably a considerable part of it, was far from being what it is represented.

THE POTOMAC DRAINAGE BASIN.—A sanitary survey of the Potomac drainage basin was made in behalf of the board, and in this connection advantage was taken of Mr. Horatio N. Parker's "The Potomac River Basin" (Water Supply and Irrigation Paper No. 192, U. S. Geological Survey). The report before us contains numerous details regarding pollution at various points in the drainage area above the source of the Washington water supply at Great Falls. The river above the point named drains about 11,400 sq. mi., on which there was in 1900 a population of some 500,000, or 44 per sq. mi. Although "typhoid fever prevails to a greater or less degree in every part of the drainage basin," yet owing to the lack of vital statistics in some of the states concerned "no data for an accurate determination of its degree or seasonal prevalence are obtainable." Apparently, however, the seasonal prevalence in the drainage area corresponds to that of Washington.

Although the Potomac receives sewage pollution at many points, the direct pollution is from not more than 45,000 people, and of this about 80% reaches the river 176 miles or more above the water-works intake; 15% between 50 and 175 miles; and 5% (from some 2,200 people) at points 19 to 50 miles above the intake. Within 19 miles of the intake "practically no direct pollution of the Potomac takes place," but this part of the drainage area is inhabited, so that "the possibility and danger of direct pollution of the river within this section cannot be ignored." Obviously, the dilution of such polluting matters as do reach the river is very great.

SAND FILTRATION AT WASHINGTON.—On the general subject of the slow sand filters at Washington, which have been in operation since the latter part of 1905, the board gives as its opinion that the "plant represents a high degree of engineering skill and intelligent management." It also says that "the water is greatly improved, both bacteriologically and chemically, by the storage and filtration, as indicated" by figures given in the report. It having been suggested that mud deposits in the Washington distributing mains were responsible for some typhoid infection, studies of this mud were made, but with negative results.

A summary of a limited number of bacterial examinations made for the board showed that storage and filtration combined reduced the total number of bacteria by 93.1%; that of 15 samples of raw water, 66.6% contained the colon bacillus, while 14.2% of 21 samples from the filtered water reservoir contained the same germ, as did also 17.5% of 131 samples of tap water. In comparison with these figures, examinations made during the same period (August and September, Sundays excepted) at the laboratory of the water filtration plant showed that storage and filtration combined reduced the total bacteria 99.3%. Examinations for coli between July 16 and Oct. 16 gave six positive results out of 100 samples of 10 c. c., and five positive, or 4% of the total number of samples, with 1 c. c. of water. Tap water was tested in each case. Chemical studies were also made by the board, but it does not seem necessary to review them here.

Inasmuch as the relation between the prevalence of typhoid in Washington and the Potomac water and its filtration has attracted so much attention, first and last, we will quote at length, in conclusion, from the boards own "summary and recommendations," giving the whole of its section on this topic:

THE RELATION OF POTOMAC RIVER WATER TO TYPHOID FEVER.

> The typhoid fever bacillus has never been isolated from the Potomac River water. We therefore have no direct evidence to prove or disprove that some of the infection may or may not be water borne. We must, then, satisfy ourselves for the present with certain indirect evidence bearing upon this important question.
>
> Despite the improvement in the water, due to storage, sedimentation, and filtration, no appreciable change in the typhoid situation is apparent.
>
> Water-borne epidemics, due to concentrated and quickly transferred infection, may occur at any time of the year, particularly in the spring and late fall. Such epidemics are generally characterized by sudden onset and sharp decline. Little is known of the characteristics of typhoid-fever outbreaks resulting from water containing greatly diluted and slowly transferred infection.
>
> The presence of typhoid bacilli in great dilution and perhaps attenuation may not have the power of directly causing the disease in persons drinking such water. Water, however, containing an occasional typhoid bacillus may infect a community in such a way that large numbers of persons become bacillus-carriers. With the advent of the hot weather many such persons may be stricken with typhoid fever, just as the depressing influence of the heat is known to determine the onset of diarrheal diseases and other intestinal infections. In other words, the presence of the typhoid bacillus in the intestinal tract has not always the power of causing typhoid fever. We must reckon with our host. The dilute and attenuated infection in the water may sow the seed; for the production of the disease we must have susceptibility, and this susceptibility may be largely brought about by the diminished resistance caused by the summer heat.*

*This same hypothesis also applies to any other means by which the infection is conveyed, such as direct and indirect contact.

We are totally ignorant of the number of bacilli ordinarily necessary to produce the disease. It is reasonable to assume that water containing the typhoid bacillus in great dilution may sometimes directly cause the disease in highly susceptible individuals. On this assumption we would expect, in a community in which the great majority of the population drink such water, the cases to be widely scattered and a very small proportion of the people to have the disease. Further, we must consider that the occasional and perhaps attenuated typhoid bacillus in water may increase in danger and virulence by contaminating milk and other beverages or foods that are favorable media for its rapid growth and multiplication.

In favor of the view that the Potomac water plays an important part in the dissemination of typhoid fever in Washington, we have the following:

The uniform distribution of the disease throughout the city, indicating a common medium, such as water.

The great majority (96.5%) of the cases studied gave a history of having drunk unboiled tap water within 30 days prior to the onset of the disease.

The majority of the population drink unboiled tap water; and so, if this water contains typhoid bacilli in dilute suspension, the chances of infection reaching the susceptible individuals are favored. During the year 1906 one person in about every 300 of the population of the District of Columbia had typhoid fever and during the season of greatest prevalence the cases which occurred during each half-monthly period were widely scattered over the District.

Colon bacilli are found in the water. These organisms are usually taken as an indication of sewage pollution; 66.6% of the 15 samples of the river water examined contained the colon bacillus; 14.3% of the 21 samples of filtered water and 17.5% of the 131 samples of tap water examined contained the colon bacillus in 1 and 10 c. c.

It is evident, therefore, that a certain number of the colon bacilli in the raw water passed the storage reservoirs and sand filters. Therefore it seems reasonable to assume that a certain number of typhoid bacilli, when present in the raw water, may also pass into the tap water.

The Potomac River at numerous points along its course receives the sewage of a number of thousands of persons.

Some of the typhoid fever in the District in former years was apparently traced to the Potomac River water. For example, the outbreak in Cumberland, Md. (December, 1889, to April, 1890), was followed by an increase in typhoid fever in the early spring in Washington. A sudden decrease in the Washington death rate followed the installation of the Dalecarlia reservoir in 1895.

The typhoid death rate for 1906—that is, since the filtration of the water—was 49.3 per 100,000. This is a much higher typhoid death rate than is usually observed for large American and European cities having water supplies of undoubted purity.

Considering that there were due to contact and to infected milk twice as many cases as we were able to attribute fairly definitely to these causes, there still remains about half of the cases unaccounted for. If the water is not a factor in the spread of the infection, then it would appear that some unknown agent or agents for the dissemination of the infection must be peculiarly active in Washington.

In favor of the view that the Potomac water plays little, if any, role in the dissemination of typhoid fever in Washington, we have the following:

The improvement in the water supply was not followed by an improvement in the typhoid fever situation.

Typhoid fever may diffuse itself broadcast throughout a community using water free from suspicion—the so-called "prosodemic" type of Sedgwick and Winslow.*

A great majority of the population of Washington drink unboiled tap water, which may be considered as diminishing the value of the suggestion that the tap water is a common factor.

The colon bacillus is not the typhoid bacillus, and the sanitary significance of the presence of colon bacilli in amounts less than 1 c. c. in river water has perhaps been exaggerated. It must be borne in mind that many colon bacilli in a surface water, such as the Potomac, derive their origin from the intestinal tracts of animals other than man.

The filtered river waters of Lawrence, Albany, Philadelphia, etc., also contain a few colon bacilli, and the total number of bacteria here compare favorably with the number found in the effluents of the above-mentioned cities. Sand filtration of the above river waters, giving a somewhat similar bacterial effluent, as judged by the total number of bacteria and the colon bacilli, has been followed by a reduction in the typhoid death rate.

According to the researches of Kinyoun and Sprague in 1897, the tap water contained the greatest number of colon bacilli during September and October, whereas the disease during that year prevailed to the greatest extent during the preceding months.

*Sedgwick, W. T., and Winslow, C.-E. A. Statistical Studies on the Seasonal Prevalence of Typhoid Fever, etc. Memoirs Amer. Acad. Arts and Sciences, XII., p. 568. 1902.

It seems that, so far as the incomplete records are obtainable, typhoid fever prevails to a great extent at the same season in Washington and over the entire watershed. This indicates that the causes, whatever they may be, act simultaneously along the entire course of the river.

While it is true that the Potomac receives the sewage directly of many thousands of persons, much of this pollution is distant and greatly diluted. Self-purification takes place to such an extent that the water at the intake averages comparatively few bacteria per cubic centimeter the year round compared with other grossly polluted streams and may be considered of fair sanitary quality compared with many such streams used for drinking purposes.

It is probably true that in former years some of the typhoid fever in Washington was due to infection in the river water; but in view of the improvement of the water by storage, sedimentation, and filtration, it would seem reasonable to suppose that the danger of infection from the water may have been largely eliminated.

Typhoid fever in Washington is mainly a summer disease. There is a great and sudden increase in the number of cases with the advent of hot weather. This seasonal prevalence repeats itself year after year with great regularity. If the bulk of the infection were waterborne, it would seem that we would have more marked irregularities of the curve from year to year, as is seen in other communities where much of the disease is plainly due to highly infected water.

The seasonal prevalence of typhoid in Washington corresponds to that of Boston, New York, Baltimore and other cities in which the water is believed not to play much part.

If we attribute the bulk of infection to imported cases, contacts and milk, then it would not be necessary to consider that some unknown agent or agents causing the dissemination of the disease must be peculiarly active in Washington.

The high death rate from typhoid fever in the District of Columbia is partly accounted for by the fact that the disease is more fatal in the colored than in the white race. About one-third (90,000) of the population are colored. During the period 1895 to 1906 the relative average death rates were:

	Per 100,000.
White	47.8
Colored	78.2
Total	57.9

The death rate for 1906, that is, since the filtration of the water, was:

	Per 100,000.
White	35.4
Colored	83.1
Total	49.3

A typhoid death rate of about 20 to 25 per 100,000 in the larger cities of Massachusetts has been attributed to causes other than infected water (prosodemic typhoid). North Adams, with a population of about 25,000, has a death rate of 39 per 100,000.

Winnipeg, with artesian water of exceptional purity, as its principal supply, has a death rate more than double that of Washington. Typhoid fever in Winnipeg is also a summer disease.

Communities have had pronounced epidemics of typhoid fever in which the water is reported to have played no appreciable part. The same is true of army encampments.

So far as typhoid fever is concerned, it seems that Washington may be classed with the Southern cities, where this disease is either unusually prevalent or unusually virulent, as indicated by the high death rates.

DEATH RATES PER 100,000 POPULATION IN VARIOUS SOUTHERN CITIES FROM TYPHOID FEVER.
(Average for a period of five years; from U. S. Census Reports.)

Alexandria, Va.	67.26	Paducah, Ky.	82.08
Atlanta, Ga.	69.54	Petersburg, Va.	92.62
Charleston, S. C.	84.38	Raleigh, N. C.	75.28
Jacksonville, Fla.	74.15	Richmond, Va.	71.16
Kansas City, Mo.	48.50	San Antonio, Tex.	57.38
Key West, Fla.	47.92	Savannah, Ga.	49.30
Lynchburg, Va.	99.22	Washington, D. C.:	63.20
Memphis, Tenn.	45.22	For 1906	49.30
Mobile, Ala.	68.34	Wheeling, W. Va.	87.40
New Orleans, La.	44.90	Wilmington, N. C.	82.52
Norfolk, Va.	54.52		

In view of the foregoing, it is evident that at the present time it is not possible to present conclusive proof as to the part played by the Potomac River water in the spread of typhoid fever in the District of Columbia. Therefore the board reserves final decision on this subject until investigations, now in progress at the Hygienic Laboratory, have been completed.

Although views may differ concerning the relative part played by water, milk, contacts and other factors in the spread of typhoid fever, there is a general agreement that the successful control of the disease lies in destroying the infection as it leaves the body; that is, we must try to prevent the infection of our food and drink and our environment.

Finally, it must be borne in mind that the typhoid problem in Washington does not differ radically from that of many other communities. It is part of a world-wide problem. The disease is endemic throughout the length and breadth of our large country and prevails to a greater or less extent in almost every civilized community. There is a constant interchange of visitors through social and commercial intercourse. The situation in Washington has therefore been considered not only with regard to local conditions, but also in relation to studies that have been made upon the disease in other cities and in other countries.

THE FIFTEENTH ANNUAL CONVENTION OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

The first three days of July saw, at Cleveland, the best attended and most enthusiastically conducted meeting that this society has ever known.

Under the direction of President Charles S. Howe, of the Case School of Applied Science, the faculty of that institution administered the local affairs incident to the meeting in a most efficient manner; both business and social meetings were well handled.

The business and technical sessions were held in the lecture room of the Rockefeller Physical Laboratary at the Case School—the arrangement of the room making it particularly adapted to such a meeting. The hotel headquarters were at the Euclid.

The morning of the opening day—Monday, July 1—was set aside for such excursions and visits as would prove of interest to various engineering works of Cleveland. At 10.30 the Council of the Society held a session at the Rockefeller Laboratory.

GENERAL SESSIONS.

At 1.30 o'clock Monday afternoon the President of the Society—Prof. Dugald C. Jackson, of the Chair of Electrical Engineering, Massachusetts Institute of Technology—called to order the opening session of the convention.

President Howe, of the Case School, delivered an address of welcome, after which the general business of the society, such as committee reports, election of new members, etc., was transacted. About 85 new members were elected at this session.

The papers to be presented were then taken up. Mr. Bassett Jones, Consulting Engineer, of 1 Madison Ave., New York, presented "The Relation of Philosophy to Science," a paper pleading for the injection into engineering educational courses of more philosophy in the abstract—psychology, logic, mental science and kindred subjects—as an addition to the equipment of the embryo engineer in his battle with the world after graduation. Mr. Jones' paper stirred up lively discussion among the more severly practical educators present; Prof. William Kent, Dean of the College of Applied Science at Syracuse University, objected somewhat ironically to dilettantism on the part of engineering students, and said, among other things, "if the modern engineer meddles with philosophy he must do it in moderate doses." This seemed to be the general sentiment of the meeting on the subject.

The next paper was of great historical interest: "Engineering Education Before and After the War," by Prof. J. Burkitt Webb, of the Chair of Mathematics at the Stevens Institute of Technology, Hoboken, N. J. The general tone of Prof. Webb's paper was that, while engineering schools were scarce in those days—six in all—it was, on the whole, easier for a young man of earnest purpose to secure a first class technical education then than now; i. e., that the training process was apt to be more thorough. "Mahogany furniture," said Prof. Webb, "used to be mahogany; now it is birch, basswood, hemlock, etc. The demand for mahogany furniture now is larger, but the scarcity of that wood is no drawback." This metaphorical statement from one of the "old timers" was hardly complimentary to the general mass of material now passing through our colleges, and has its partial justification in the superficiality of some modern educational methods. There was no discussion of this paper.

"Engineering Chemistry and Chemical Engineering" was then presented by Dr. Charles F. Mabery, Professor of Chemistry at Case School.

this paper pointed out the distinction between the broad thoroughness of a "straight chemistry" course and a course for training a chemical engineer; Prof. Mabery made a strong plea for the devotion of more time to laboratory work, even though it extend the length of the course.

William G. Raymond, Dean of the College of Applied Science and Professor of Civil Engineering at the University of Iowa, presented a paper upon a subject for which he has stood sponsor at previous meetings of the society—that of individual instruction of engineering students. The title of his paper, "An Educational Experiment," shows that it is still in the experimental stage, even with Prof. Raymond. He stated, however, that on the whole his experiment had proved a success; it was performed upon 20 volunteers from among the civil engineering students at the University, who made as much or more progress studying independently as did those working under the old class system.

Read in conjunction with Prof. Raymond's paper was one along kindred if not similar lines by Dean Kent, of Syracuse—"Pedagogic Methods in Engineering Instruction." The most prominent point brought out in this paper was that of the preservation of lectures by mimeographing and, later, printing: "Any lecture worth delivering is worth duplicating," said Prof. Kent; and while adverse criticism of this dictum was given in later discussion, we are inclined to agree with its author on the ground that too close concentration upon his notebook and pencil by a student following a lecture prevents his getting a broad, comprehensive view of the subject treated.

Discussion was opened upon the three papers last read, and the fire was concentrated in the main upon Prof. Raymond's paper. Professors F. E. Turneaure (U. of Wis.), Geo. R. Chatburn (U. of Neb.), Wm. Kent (Syracuse), Wm. T. Magruder (O. State U.), A. L. Williston (Pratt Inst., Brooklyn), Howe (Case), Pres. Jackson of the Society, and others of equal prominence contributed to the interest; it was notable, and drew comment thereon from Prof. Raymond himself, that while four or five years ago his "hobby" of individual instruction had been viewed with suspicion by most of the members, disciples of the individual instruction system were increasing in number. Qualified assent to this was given from several sources, though some maintained that he went too far in that direction and that a more conservative division of classes into sections, basing the division on the relative mental qualities of the men, would produce better aggregate results.

Mr. James M. White, Professor of Architectural Engineering and Dean of the Engineering College, University of Illinois, presented "The Relative Efficiency of Instruction in Engineering Subjects." This was a paper, illustrated by comparative tables, concerning the proper balancing between the number of instructors and the number of students handled and subjects taught, to obtain the most economic results financially; it led to methods of measuring the work of different departments, and to the determination of equalizing factors which would place all courses on a common basis. While this paper was mainly along the line of internal routine in college work, discussion was quite extended and was carried over into the opening of the evening session.

The second general session was called to order at 7.30 p. m. After further discussion on Dean White's paper, John W. Shuster, Assistant Professor of Electrical Engineering at the University of Wisconsin, described "The Organization and Conduct of an Electrical Engineering Laboratory;" "Some Notes on Central Station Design," a description of the work of students in practical station designing was also presented by Albert A. Radtke, Professor of Electrical Engineering at the Armour Institute of Technology.

Prof. Kent, in discussing the second of these papers, told of setting his own students at work studying conditions at Syracuse with a view to designing a possible steam plant there to compete with the Niagara power; dividing the class into committees, each of which covered a different phase of the question. One of the designs prepared by a committee was deemed good enough, by the Harrison Boiler Works of Syracuse, to enter in a competition which they were conducting. This work in actual practice was regarded as one of the strongest features of advanced college work, in that it gives the student confidence and enables him the better to articulate the theory of his earlier instruction with subsequent real problems.

In the absence of Prof. Stephen E. Slocum, of the Chair of Applied Mathematics, University of Cincinnati, Prof. Magruder read his paper on "Basic Principles in the Construction of a Text-Book." Closely akin to this paper was Prof. H. H. Norris' paper on "Methods of Studying Current Technical Literature," also read by Prof. Magruder.

The first of these was mainly aimed at methods of teaching mathematics, but touched upon other subjects somewhat. It considered the three essential requisites: (1) Stimulation of interest in a subject; (2) utilization of this interest for the mastery of fundamental principles; (3) acquirement of proficiency in their practical application.

The second opens up a question of great interest to makers of current technical literature, and we are glad to see the interest that is shown by various institutions in this phase of their instruction work. Prof. B. B. Brackett, of Physics and Electrical Engineering at the Clarkson Memorial School of Technology at Potsdam, N. Y., holds a "journal meeting" once a week for the study of the week's literature. Dean White, of the University of Illinois, has an indexing system for articles in current journals, for use in conjunction with text-book instruction. The tendency to consider current engineering journals in the light of supplementary texts for instruction is gratifying to those who are engaged in providing timely articles for the profession; it may be admitted that it is perhaps unwise that students be "turned loose" unguided, to read at random; but, properly guided in their selection, they may derive practical information of great value in this manner.

The closing paper of this session was by Dayton C. Miller, Professor of Physics at the Case School, on "The Building and Equipment of the Rockefeller Physical Laboratory of the Case School." In conjunction therewith, Prof. Miller gave some demonstrations of the conveniences of the lecture room, the appliances, electrical connections, etc., of the demonstration desk, and an exhibition of the projection lantern. After this paper the visitors were shown through the building by the members of the Case faculty.

On account of the crowded condition of these columns it is necessary to complete the report of this convention in another issue. Accordingly, the work of the Tuesday and Wednesday sessions will be presented next week.

AN OPEN ELECTRIC CAR on the Fairmont and Clarksburg Traction Co.'s road in West Virginia left the track just outside of Clarksburg on July 7 and went over an embankment. Two passengers were killed and 10 injured.

TWO HEAVY INTERURBAN ELECTRIC CARS on the International Railway Co.'s Lockport (N. Y.) line collided head-on at North Tonawanda on July 5, while running about fifteen miles an hour. Two persons were killed and 35 injured. The motorman of the northbound car is said to have run past the proper meeting point.

A RUNAWAY ELECTRIC CAR on the Thirty-fourth Street crosstown line, New York, caught a horse car between it and another electric car in front of the latter on July 8, and caused the injury of 20 persons. The horses were crushed against the front car and had to be shot. Failure of the brakes caused the runaway, which occurred just after the car had turned the corner into First Avenue.

THREE ELECTRIC CARS collided at East Providence, R. I., on the morning of July 4, killing one and injuring 40. Two open cars, bound for Providence, were standing about 20 ft. apart at the foot of a steep grade near the Washington Bridge over the Seekonk River. A closed car from Taunton, standing at the top of the grade, started down; the air brakes, it is said, failed to work when applied, and the closed car ran into the nearer of the open cars and drove it into the other one.

A HEAD-ON COLLISION BETWEEN AN ELECTRIC car and a work train on the Washington, Arlington & Falls Church line, 3½ miles from Washington, D. C., killed one passenger and injured 35 or more on July 3. The collision was on the Virginia side of the Potomac, on a steep hill and curve near the Fort Myer Courthouse; the passenger car was late, and was running toward the city, down this grade; a special had passed outward on the line, and had passed the work train on a siding. The work train left the siding after this car had passed and started up the grade, when the passenger car met it at high speed. Responsibility is placed on the crew of the special, who had been told to warn the incoming car to take a siding and allow the work train to pass. They forgot to deliver the orders. A less antiquated method of signaling, not dependent upon fallible human memory, would have saved considerable suffering.

THE BUFFALO EXPRESS on the Pennsylvania R. R. was wrecked at Sunbury, Pa., on July 2, in a head-on collision with a freight train. Three persons were killed and about fifteen more injured. The crew of the freight—a Sunbury and Lewiston coal train—pulled out of a double switch southward, thinking they were on the south-bound track; the Buffalo train came through at that moment to the northward.

THE CABLE ON THE INCLINED RAILWAY at Niagara Falls, on the American side of the Gorge, broke on July 6 and allowed both cars to plunge to the foot of the incline, which terminates at the wharf for the steamer "Maid of the Mist." Several people were injured more or less seriously.

A PAIR OF LOCK GATES ON THE CORNWALL Canal in Canada were wrecked by a steam forge on July 5. The Montreal "Gazette" reports the occurrence as follows:

> The steam barge "Ionia" tore two gates out of lock 17 of the Cornwall canal this evening and thereby tied up navigation. As far as can be learned the "Ionia's" lines were not tight enough and after the lower gates were closed behind her and the dock was being filled she surged ahead and crashed into one of the upper gates, displacing it. The weight of water on the level tore off the other gate, and although the steamer was given full steam ahead she was carried back by the water and damaged the lower gates which, however, fortunately, held.
>
> Canal Overseer Frank Lally at once turned out the repair gang and the gate lifter was set at work to replace the gates, divers being sent to the bottom to clear away wreckage and gravel.
>
> Mr. Lally says that unless the track is damaged the canal will be ready for navigation early tomorrow.
>
> Lock 17 seems to be hoodoed, and the past dozen years or so its gates have been carried away three times by the steamer "Ocean," the barge "Kildonan" and steamer "Hepburn." It is fortunate that the "Ionia" was not a heavier craft else the lower gates would surely have been wrecked, and perhaps lock 16 as well.

A BREAK IN THE BUENA VISTA LAKE LEVEE, near Bakersfield, Cal., is reported as having occurred on July 3. It is stated that a large area of land was flooded and that much damage was done to crops, and that communication between Bakersfield and the oil fields of the vicinity by means of the Sunset Railway was cut off. It is stated that the levee was built in 1866-7 by Mills & Laux and the Tevis Land Co., for the protection of a large area of reclaimed land.

OILING THE ROADBED has been commenced by the Oregon R. R. & Navigation Co. between Pendleton, Ore., and Starbuck, Wash.

BIDS FOR CONSTRUCTING MAIN DAMS for the Ashokan Reservoir will be received by the Board of Water Supply of New York City on Aug. 6. These dams (see Eng. News, May 9, 1907) will be located near Brown's Station in the towns of Olive and Marbletown, Ulster County, N. Y. Besides work for controlling stream flow at the proposed Olive Bridge dam and at the middle dike, the work will include the following main items, from which its great magnitude can be seen:

2,055,000 cu. yds. earth excavation;
425,000 cu. yds. rock excavation;
7,055,000 cu. yds. refilling and embanking;
210,000 cu. yds. soil for surface dressing;
1,100,000 bbls. Portland cement;
280,000 cu. yds. concrete masonry;
530,000 cu. yds. cyclopean masonry;
64,000 cu. yds. concrete blocks;
125,000 sq. ft. face dressing for concrete;
95,000 cu. yds. dry rubble paving;
929,000 lbs. cast and wrought iron, steel and bronze; Caring for and setting 90,000 lbs. of metal work furnished by the city;
200 acres clearing;
11,500 lin. ft. vitrified pipe not exceeding 10 ins. diam.;
10,000 lin. ft. vitrified pipe not exceeding 18 ins. diam.;
950 M. ft. B. M. timber and lumber.

The time allowed for the completion of the work will be 84 months from its official beginning. Mr. J. Waldo Smith, M. Am. Soc. C. E., is Chief Engineer; Mr. Carleton E. Davis, Assoc. M. Am. Soc. C. E., is Engineer of the Reservoir Department, with office at Brown's Sta-

tion, N. Y. Mr. J. Edward Simmons is President of the Board of Water Supply, the main offices of which are at 299 Broadway, New York City.

A THIRD TRACK for the Second and Third Ave. lines of the elevated railways of New York City has been recommended to the new Public Utilities Commission by Mr. Geo. S. Rice, M. Am. Soc. C. E., Chief Engineer. These tracks are advised because they are the only relatively speedy means of increasing the greatly-needed transit facilities between Manhattan and Bronx boroughs. It is stated the commission will not take immediate action on the recommendation.

STALLED TRAINS MUST TELEPHONE THE TRAIN dispatcher on the Pennsylvania R. R. system, after July 1, according to a Pittsburg dispatch. Telephone wires have been run along the tracks and a train stopped at any point where no stop is scheduled must notify the dispatcher at once, by means of a portable telephone set, carried in each train, and also notify him when the train is ready to move. It is probable that the rule does not apply to lines operated under the block system.

THE GASOLINE MOTOR CARS of the Union Pacific Ry., which have been illustrated and described in our issues of April 6 and Dec. 21, 1905, and Nov. 22, 1906, are to be used for regular traffic after long experimenting. It is now reported that 12 of these cars are to be put in service shortly for branch line traffic, where the fast and frequent service desired cannot be economically maintained by ordinary trains. These cars were designed by Mr. W. R. McKeen, Jr., Superintendent of Motive Power, and have all been built at the company's shops at Omaha. The latest cars have engines of 200 HP.

GAS ENGINES USING BLAST FURNACE GAS are to replace steam engines for blowing furnaces at all the plants of the United States Steel Corporation, according to a Pittsburg dispatch of July 1.

INSUFFICIENT POSTAGE PREPAYMENT on foreign mail matter is often the cause of loss of business by American manufacturers and exporters. In one instance some advertising matter was sent to a South American firm with postage underpaid. The firm receiving the matter paid the amount of shortage and also the fine imposed on underpaid matter, and sent a courteous letter to the American firm, calling attention to the error. The American firm sent a letter of apology by the next mail, but put insufficient postage on that letter also.

RED AND YELLOW FIR TIMBER STRINGERS will run about the same in strength and stiffness according to recent tests made by the U. S. Forest Service. Both red and yellow fir are secured from the same species, Douglas fir, and often from the same tree and are therefore very hard to differentiate by outward appearance. The investigations show that the yellow is of slower growth than the red and that it also ranges higher in grade. Of the 94 yellow fir stringers tested 47.8% were selects, 40.4% were merchantables, and 11.8% seconds. Of the 102 red fir stringers tested 29.8% were selects, 43.8% were merchantables, and 26.6% seconds. Grade for grade, however, the variation in fiber stress at elastic limit, modulus of rupture and modulus of elasticity did not exceed 6% in the two species. The distinction between the two is therefore only of academic interest and in construction they may be used with equal success.

PERSONAL.

Mr. P. G. Ten Eyck, formerly Treasurer and Chief Engineer of the Federal Railway Signal Co., has been appointed Vice-President, with offices at Albany, N. Y.

Mr. Leroy Leach has been appointed Assistant State Engineer of South Dakota. His first work will be a series of hydrographic surveys of the streams used for irrigation in the western part of the state.

Mr. W. H. Fuller has resigned the position of Chief Engineer of the Omaha & Nebraska Central Ry., to become assistant to Mr. T. H. Bacon in the location of a railroad through the Bitter Root Mountains of Montana and Idaho.

Mr. Dow F. Smith, who has long been General Superintendent of the Brooklyn Rapid Transit Co., has resigned. Mr. Wm. S. Menden, M. Am. Soc. C. E., who has been Chief Engineer, will succeed him as General Superintendent.

Col. Smith H. Leach, Corps of Engineers, U. S. A., has been assigned as the principal assistant of the chief of engineers. He succeeds Major Harry F. Hodges, who has been appointed General Purchasing Officer of the Isthmian Canal Commission.

Mr. H. M. Beugler, formerly Superintendent of Railways for Ford, Bacon & Davis, operating the Newman properties in Houston, Tex.; Memphis, Nashville and Knoxville, Tenn.; Birmingham, Ala., and Little Rock, Ark., has taken a position with Dodge & Day, of Philadelphia, Pa.

Mr. Geo. L. Watson, Jun. Am. Soc. C. E., has resigned the position of Assistant Chief Engineer of the Fidelity Construction Co., of Detroit, Mich., to open an office as consulting engineer in the Baxter Bldg., Philadelphia, Pa. Mr. Watson has opened branch offices at Holly Beach, N. J., and Pottsville, Pa.

Mr. Joseph Hobson, M. Am. Soc. C. E., formerly chief engineer of the Grand Trunk Ry. System, has become Consulting Engineer. Mr. H. G. Kelley, M. Am. Soc. C. E., formerly Chief Engineer of the Minneapolis and St. Louis R. R. and of the Iowa Central Ry., becomes Chief Engineer of the Grank Trunk System.

Mr. R. P. Stevens, former Superintendent of the Auburn & Syracuse R. R. (electric), has been elected President of the Lehigh Valley Transit Co., which operates 142 miles of electric railroad north from Chestnut Hill (Pa.). Mr. Stevens has had wide experience in electric railroad building and operation, though he is but 31 years old.

Mr. Harris Tabor, M. Am. Soc. M. E., a well known consulting engineer of Philadelphia, had a serious automobile accident at Doylestown, Pa., on July 6, and, with Mrs. Tabor, narrowly escaped death. Their machine went over a precipice and they fell 75 ft., being saved only by a growth of shrubs 25 ft. above the base of the cliff. Both were badly injured.

Mr. Ralph D. Mershon, M. Am. Inst. E. E., Consulting Engineer, of New York City, sailed on July 2 for England on his way to South Africa, in connection with the work of the Victoria Falls Power Co. Mr. Mershon will be absent about 100 days in consultation relative to the location of the steam stations and local distribution circuits for this power development.

Mr. Alfred E. Forstall, M. Am. Soc. M. E., Consulting Engineer, of 58 William St., New York, has been appointed by the Public Utilities Commission as a consulting engineer to prepare a complete and adequate system for the inspection and sealing of gas meters, including the handling of complaints, preservation of records, and instruction of inspectors. His work will be under the direction of Commissioner Milo R. Maltbie.

Mr. Hermann von Schrenk has resigned his position as Pathologist in the U. S. Department of Agriculture, in charge of the investigation of timber diseases and their remedies, to associate himself with Mr. E. B. Fulks and Mr. Alfred L. Kammerer, who have been connected with the timber preserving work of the Department. They will carry on a business as consulting timber engineers, under the firm name of Von Schrenk, Fulks & Kammerer, with offices at St. Louis, Mo.

Mr. B. M. Hall, of the U. S. Reclamation Service, has accepted an appointment as Consulting Engineer for the Insular Government of Porto Rico, to investigate the water supply and submit plans for irrigation. He has been Supervising Engineer in charge of the work of the service in New Mexico and Texas, and proposes now to engage in consulting practice in Atlanta, Ga. His connections with the Reclamation Service are not entirely severed, as he will be retained as its Consulting Engineer, available for special duty as required. The Porto Rico work will require about two months.

Obituary.

George Rowland, M. Am. Soc. M. E., Assistant Treasurer of the Continental Iron Works, Brooklyn, and youngest son of its President, Thomas Fitch Rowland, died at the family's summer home at Larchmont, N. Y., on July 8, at the age of 42.

James Macbeth, Master Car Builder of the New York Central & Hudson River R. R., at East Buffalo, died on July 5 at his Buffalo home. He was a well-known railroad man, having begun his railroad life in America in 1859; he was a native of Aberdeen, Scotland. In 1864 he became foreman of repairing and rebuilding of locomotives in the New York Central shops. He held various responsible positions until, in 1893, he was appointed to the position now made vacant by his death. He was an honored Past-President and one of the founders of the Central Railway Club, a member of the Board of Councilmen of Buffalo, and a member of various Masonic bodies, including the Knights Templars.

Louis Magee, Assoc. Am. Inst. E. E., died on July 3 at his home, 80 Madison Ave., New York City. Mr. Magee was born in Malden, Mass., in 1862, and graduated from Wesleyan University in 1885. He immediately entered the shops of the old Thompson-Houston Electric Co. He spent some time in Peru in charge of work and in 1899 became manager of the European offices at Hamburg, Germany. In 1892 he organized the Union Electricitäts-Gesellschaft, of Berlin, and remained as managing director, until that company was merged in 1903 with the Allgemeine Electricitäts-Gesellschaft. Since 1904 he represented the latter company in this city, with offices at 25 Broad St. He had been connected since his return to the United States with the arrangements between the General Electric Co., Schenectady, and the Allgemeine Electricitäts-Gesellschaft, for the exchange of men for foreign technical experience. Mr. Magee was a contributor to magazines on German and technical subjects. He leaves a widow, who is a daughter of the late Dr. Henry B. Kent of New York City.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION.
July 17-19. Annual convention at New York City. Chairman National Committee, J. C. Hatzel, 571 Fifth Ave., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23-29. Annual convention at Toronto, Ont. Secy., R. W. Raymond, 29 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
July 29. Annual convention at Seattle, Wash. Secy., Edw. A. Moseley, Interstate Commerce Commission, Washington, D. C.

ILLUMINATING ENGINEERING SOCIETY.
July 30-31. First annual meeting at Boston. Secy., Dr. A. H. Elliott, 4 Irving Place, New York.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 7-9. Annual meeting at Norfolk, Va. Secy., Frank P. Foster, Corning, N. Y.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, Oswego, N. Y.

ILLUMINATING ENGINEERING SOCIETY.—The business headquarters of the First Annual Convention at Boston, Mass., July 30 and 31, will be in Room 728, Old South Building. The program of papers is not announced, but probably will be published this coming week.

AMERICAN INSTITUTE OF MINING ENGINEERS.—At the 93d meeting of the Institute, to be held at Toronto, Ont., beginning Tuesday afternoon, July 23, the following arrangements will be generally in force: the program is provisional and subject to possible changes.

Headquarters will be at the King Edward Hotel. The proximity of Toronto to the new mining field about Cobalt will be taken advantage of during the meeting. Tuesday, July 23, afternoon, session at the King Edward Hotel; evening, reception in the Parliament Buildings. Wednesday, July 24, morning and afternoon, sessions at the hotel; evening, departure at 9 P. M. by special train for Cobalt. Thursday, July 25, visits to mines and an evening reception at the Cobalt opera house. Friday, July 26, additional visits to mines; optional excursions to points of scenic or scientific interest. Saturday, July 27, steamer trip up Lake Temagami; optional trips in the mining district. Sunday, July 28, to be spent at hotels at or near Lake Temagami. Monday, July 29, visit to Sudbudy, etc., to be continued on Tuesday, the party returning to Toronto by train leaving Sudbury Tuesday night.

Following is a list of papers which may be expected:

"Some Reflections on Secrecy in the Arts," by James Douglas, New York City; "The Willey Table," by R. H. Richards, Boston, Mass.; "The Tar-Sands of the Athabaska District," by Robert Bell, Ottawa, Can.; "The Occurrence of Nickel in Virginia," by Thomas L. Watson, Blacksburg, Va.; "Coal-Briquetting in the United States," by E. W. Parker, Washington, D. C.; "The Electric-Air Drill," by W. L. Saunders, New York City (illustrated with lantern views); "Notes on the Cobalt and Sudbury Mineral Areas," by Willet G. Miller, Toronto, Can. (illustrated with lantern views); "Geology of the Virginia Barite Deposits," by Thomas L. Watson, Blacksburg, Va.; "The Effect of High Litharge in the Crucible Assay for Silver," by Richard W. Lodge, Boston, Mass.; "Physical Factors in the Metallurgical Reduction of Zinc Oxide," by Woolsey McA. Johnson, New York City; "Zinc Oxide in Iron Ores and the Effect of Zinc in the Iron Blast-Furnace," by John J. Porter, Cincinnati, O.; "Chronology of Lead-Mining in the United States," by Walter R. Ingalls, New York City; "The Promontorio Mine," by Francis C. Lincoln, New York City; "Blow-Holes in Steel Ingots," by E. von Maltitz, South Chicago, Ill.; "The Evergreen Copper Deposit," by Etienne A. Ritter, Colorado Springs, Colo.; "Pure Coal as a Basis for the Comparison of Bituminous Coals," by W. F. Wheeler, Urbana, Ill.; "Quantitative Field-Test for Magnesia in Cement Rock and Limestone," by Charles Catlett, Staunton, Va.; "The Production of Converter Matte from Copper Concentrates by Pot-Roasting and Smelting," by George A. Packard, Boston, Mass.; "The Panoramic Camera Applied to Photo-Topographic Work," by Charles W. Wright, Washington, D. C.; "Notes on the Present Sources and Uses of Vanadium," by J. Kent Smith, Pittsburgh, Pa.; "The Mines of San Juan Nepomuceno del Doctor," by T. D. Murphy, Mexico City, Mex.; "Discussion of Paper," by H. M. Howe, on "Piping and Segregation in Steel Ingots," by Alfred C. Lane, Lansing, Mich.

Of these papers, the first seven will probably be presented in full or in oral abstract by their authors.